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Edited by
Cheyenne Maddox and Lauren Barredo

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Contents

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Preface to "The 9th International Conference on Sustainable Development"

The Global Association of Master's in Development Practice (MDP) Programs, in collaboration with the Sustainable Development Solutions Network (SDSN), hosted the Ninth Annual International Conference on Sustainable Development (ICSD) on 20–21 September 2021, virtually. The conference theme was "Research for Impact: An Inclusive and Sustainable Planet". The aim of the conference was to bring together persons involved in research, policy, practice, and business. Participants shared practical solutions for achieving the UN Sustainable Development Goals (SDGs) at local and national levels. The event accepted abstracts in 22 different themes surrounding the topic of sustainable development.

Cheyenne Maddox and Lauren Barredo
Editors

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Proceeding Paper

Macroeconomic, Food and Energy Security Implications of Water Dependency under a Changing Climate: A Computable General Equilibrium Assessment †

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† Presented at the ICSD 2021: 9th International Conference on Sustainable Development, Virtual, 20–21 September 2021.

Abstract: Water, food and energy are three interconnected fundamental needs. Climate change potentially hinders the security of all of them, acting as a threat multiplier. Accordingly, this paper addresses the consequences of two climate scenarios in the 2030 horizon: specifically, it addresses the highest and lowest representative concentration pathway (RCP), 8.5 and 2.6; the relative changes in freshwater availability; and their sectorial and macroeconomic impacts. Furthermore, it addresses the importance of developing the simulations through a dynamic computable general equilibrium (CGE), which, uncommonly, explicitly considers the water endowment as a factor for both the irrigated agriculture and the energy sector. The results highlight that both the activation of the water–energy link and climate-induced freshwater availability changes have significant impacts on the simulation outcomes, even in the short-term horizon of 2030. Moreover, it reveals that water scarcity issues are expected to arise in the Middle East, leading to significant food security issues, as well as to significant consequences for the behaviour of the energy sector. Indeed, while we would expect that dependency on a scarce resource would lead to security issues, the Middle East energy sector appears to not straightforwardly behave as a resource attractor, likely due to its economic relevance both within the region and internationally.

Keywords: water–food–energy nexus; computable general equilibrium models; climate change; water modelling

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1. Introduction

Food and energy are two basic needs, fundamental for both sustainable development and the general thriving of the humankind [1,2]. Both are part of the concept of a water–energy–food nexus, an idea that stresses the notion of interconnectedness and the necessity of addressing the reciprocal influences between resources [3,4]. Historically, resource security studies were developed through separate assessments, but after the introduction of the nexus there was an increasing recognition of the fundamental need to account for influences and externalities to properly address security assessment issues [5–7].

Hence, there is a growing need for instruments able to perceive the connections between these factors. This work contributes to the nexus research field, improving a dynamic computable general equilibrium (CGE), ICES [8,9], expanding the explicit connection between water as an endowment and irrigated agriculture, which is usually well-addressed in the general equilibrium modelling literature, with water as an endowment also for the energy sector, an uncommon trait in CGEs [10,11].

Hence, there are two main aims of this study: on the one hand, it evaluates the relevance of the methodological modification in CGEs to implement a direct connection

between water and energy and have a better perception of the nexus in the models. On the other hand, it assesses the consequences of freshwater availability changes relative to two RCPs in the 2030 horizon in terms of food, energy security and macroeconomic impacts. The freshwater availability assessment highlights Middle East as a particularly vulnerable area, being the only region subject to freshwater constraints in this timeframe. Thus, the last section focus on the analysis of sectoral and macroeconomic consequences relative to water scarcity in this specific region.

Accordingly, Section 2 describes our materials and methods, Section 3 presents the results, Section 4 discusses the findings, and Section 5 draws the conclusions.

2. Materials and Methods

The model used to develop the simulations was specifically adapted to have a comprehensive view of the water–energy–food nexus in a CGE, particularly focusing on the usually overlooked water dependency of the energy sector and the consequent competition between irrigated agriculture and energy for water. Indeed, while several CGEs explicitly address the link between water resources and irrigated agriculture in the models (e.g., [12–14]), very few explicitly expressed the link for the energy sector, e.g. [15,16], and without explicit acknowledgement of the nexus issue per se, the resulting sectoral competition issues, or its implications in climate change assessments.

The main idea was, therefore, to create a model that could perceive the connections to water for both sectors, highlighting the eventual competition and security issues in its simulations, especially in a context of climate-induced water constraints. Accordingly, the framework was built following a common methodological approach in the literature [14,17] and by implementing an almost Leontief configuration for the water endowment substitution with other endowments as in [18–20], to stress the importance of water endowment in the production processes. The economic values of water were assigned based on [21] for irrigated agriculture and on [22,23] for the energy sector. The main description of the changes is shown in Figure 1. For a detailed description of the methodology, we refer to [11].

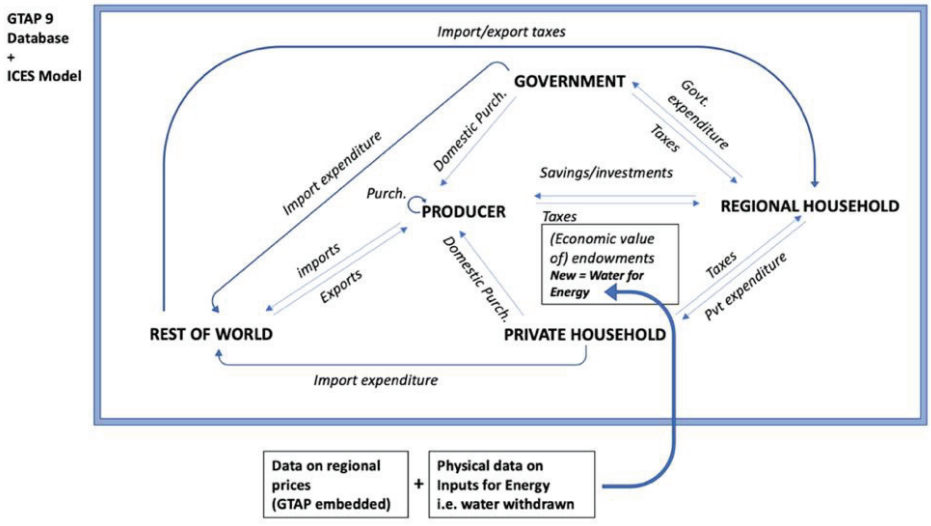

Figure 1. Representation of the main methodological changes (based on [11,24]).

For simplicity and data availability reasons, the simulations were carried out in a 10-region and 5-sectors aggregation (Regions: OECD Europe, OECD Americas, OECD Oceania, other Europe–Eurasia regions, Asia, China, India, the Middle East, Africa, and Latin America. Sectors: irrigated agriculture, rainfed agriculture, energy, industries, and services) from the database GTAP9 [25]; with base year 2011. Therefore, the framework was updated to explicitly model the water–energy link and assess how much this can influence future expectations in terms of food and energy security as well as the implications of

a climate change assessment itself. This feature, in particular, allows for a more precise analysis of the impact of eventual shocks on the prices, output, consumption, and security in the relevant sectors, as well as the overall macroeconomy.

Therefore, the experiments carried out in this paper aim to address the macroeconomic and security consequences of the mitigation and adaptation of a socio-economic pathway (SSP) [26–28], the SSP2, combined with freshwater changes expectations relative to two representative concentration pathways (8.5 and 2.6) in the 2030 horizon. The focus is particularly targeted towards the analysis of how the climatic and social projections will affect freshwater availability and security, the resulting production and consumption of food and energy and the general regional macroeconomic expectations. In particular, the main experiment aims to simulate the impacts of water withdrawal changes generated by two different RCPs [29], RCP 8.5 and 2.6, and their consequences against a baseline that replicates the economic and population growth of the SSP2 based on IIASA's projections [30,31]. The experiment was carried out twice, i.e., before and after the introduction of a direct connection between water endowment and the energy sector, to underline and quantify the importance of an explicit representation of the elements of the nexus in the model.

Concerning the climatic shock calibration, the supply of water was computed using the FAO AQUASTAT Database [32] values for the total average renewable water resources for the period 2008–2012, which were projected following the changes in the median regional total runoff variable from ISIMIP [33,34] for the RCPs: 8.5 and 2.6 (highest and lowest paths). Climate forcing was addressed through GFDL-ESM2M, bias correction target through EWEMBI, and the hydrological model was H08; no social or CO_2 cross fertilization was assumed. Considering the uncertainty relative to the physical data projections (e.g., [35,36]) to properly evaluate the issue, we should have adopted a multi-model calibration approach. Nevertheless, the present work only uses one of the physical model compositions and two climate scenarios as a complete multi-model assessment was out of the scope of the present work. Furthermore, in this context, we assumed that there were no significant changes in the regional water withdrawal levels. Indeed, even if technological changes or economic and demographic pressures could result in variations in the regional amount of water withdrawn when compatible with the freshwater availability, the lack of data availability and the short-term characteristics of the 2030 horizon led us to assume that regional water withdrawal levels were static, even if there is space for the development of more detailed scenarios in future studies.

3. Results

3.1. Baseline Results

The baseline calibrates the scenario through the total factor productivity, based on GDP trends and the population growth in SSP2. This leads to changes in sectoral production, as shown in columns one and four of Table 1 To quantitatively understand the importance of the water–energy link, the data are reported for before and after the activation of the water–energy link (top and bottom parts of the table).

In general, there could be a potential food security issue for OECD America, OECD Oceania, Other Europe–Eurasia and China, which decreases their irrigated agriculture internal demand (qdp) and significantly increases its foreign demand (qpm) in both specifications. This implies a shift towards a more internationally dependent provision of the good, which could lead to potential security issues. Nevertheless, this is not necessarily the case. For example, China is the region with the highest rainfed production potential; therefore, a strong reduction in and dependency on irrigated agriculture does not necessarily have to be interpreted as a risk of food security.

Table 1. Water-dependent output and domestic and foreign household demand between now and 2030. (Model with and without the activation of the water–energy link).

	Only Irrigated Agriculture					
	Irrigated Agriculture			Energy		
Region	qo	qpm	qpd	qo	qpm	qpd
OECD Europe	42.47	10.69	−7.31	24.35	165.94	67.11
OECD America	28.68	92.72	−12.88	18.09	207.10	68.85
OECDAOceania	24.33	9.74	−9.93	−13.87	207.55	36.43
OtherEuEurasia	56.16	39.63	−22.62	64.15	151.36	106.08
Asia	91.37	36.10	15.70	232.75	73.86	151.64
China	181.64	131.75	−35.16	556.43	−43.97	224.84
India	223.57	−15.89	59.25	794.33	−61.41	361.19
Middle East	30.00	5.49	−17.91	46.17	90.97	59.83
Africa	84.10	16.93	16.26	178.18	135.33	146.86
Latin America	50.43	28.15	−1.66	43.71	215.90	119.13
	Irrigated Agriculture and Energy					
	Irrigated Agriculture			Energy		
Region	qo	qpm	qpd	qo	qpm	qpd
OECD Europe	61.85	3.01	0.90	28.17	39.67	6.18
OECD America	93.31	76.77	−6.65	−32.02	285.53	−25.35
OECDAOceania	18.66	39.20	−13.57	117.12	−21.12	0.12
OtherEuEurasia	33.76	77.50	−17.92	106.42	98.01	84.68
Asia	78.77	66.13	22.52	286.79	99.68	109.67
China	201.99	215.23	−40.55	81.39	531.08	48.04
India	199.70	37.39	51.02	754.62	−60.23	237.81
Middle East	22.89	27.13	0.25	74.18	63.94	51.87
Africa	68.04	69.61	28.44	183.06	149.08	127.73
Latin America	42.59	58.48	1.29	111.50	82.31	67.96

The activation of the water-energy link produces significant changes in the production and import dynamics of both sectors. For example, in the active scenario, OECD Europe produces more, increases its domestic demand, and reduces its foreign demand in irrigated agriculture, i.e., endowment competition between sectors influences regional specialization choices and leads to a decrease in food security risks in the region. The strong effects of the activation of the water–energy link can also be detected in the energy sector. Indeed, for example, the Other Europe–Eurasia region significantly increase their energy production in the energy-dependent model. On the other hand, OECD America and China drastically reduce their energy production with respect to the inactive scenario, signalling a potential withdrawal of water from energy to be redistributed to agriculture and potential energy security issues. Focusing on the scenario with the water–energy link activated, the most significant potential security issue arises in OECD America, which decreases its energy output and domestic demand for goods, a strong signal of increasing energy insecurity in the region. Less strong, but still significant, is the energy security issue in China, which is expected to substantially increase energy requests from abroad, making the country more dependent on political agreements and eventual external shocks. The production behaviours of these regions are coherent with the fact that both OECD America and China have high-water-intensive energy production structures; therefore, the greater security

issues when accounting for water dependency can be explained by the technological and production configuration of these regions.

3.2. Freshwater Limit Assessment

To evaluate the eventual climate-induced freshwater scarcity, the amount of regional available freshwater was projected according to the expected median runoff variation under RCP 8.5 and 2.6 between now and 2030 (Table 2). These quantities were then compared to the levels of water withdrawal, considering only irrigated agriculture and agriculture and energy, assuming no technological changes and no fluctuations in the regional withdrawal levels. Under these conditions, most of the regions will not face a water availability problem between now and 2030. The only exception is the Middle East. Indeed, in this region, the water withdrawal level is too high with respect to the changes in the availability of in the 2030 horizon.

Table 2. Freshwater withdrawal coherency assessment (10^{12}) m^3/yr.

Regions	Freshwater Available			Water Withdrawn (I. + E.)	Water Withdrawn (I.)	Diff AV-W (I. + E.) 8.5	Diff AV-W (I. + E.) 2.6	Diff AV-W (I.) 8.5	Diff AV-W (I.) 2.6
	2011	2030_8.5	2030_2.6						
OECD Europe	2.59	2.75	2.82	0.15	0.09	2.60	2.66	2.66	2.73
OECD America	7.36	7.62	8.62	0.50	0.26	7.12	8.12	7.36	8.36
OECD Oceania	1.32	1.58	1.73	0.069	0.064	1.51	1.67	1.51	1.67
OtherEuEurasia	5.73	4.98	6.68	0.26	0.17	4.72	6.42	4.81	6.52
Asia	8.38	7.04	14.1	0.70	0.69	6.34	1.34	6.35	1.34
China	2.84	5.89	12.5	0.54	0.43	5.35	1.19	5.46	1.20
India	1.91	3.96	8.40	0.75	0.71	3.21	7.65	3.25	7.69
Middle East	0.26	0.11	0.037	0.21	0.20	−0.097	−0.17	−0.094	−0.17
Africa	2.84	1.96	3.26	0.23	0.22	1.73	3.04	1.74	3.04
Latin America	17.8	6.78	141	0.16	0.14	6.62	141	6.63	141

Accordingly, Figure 2 shows that water withdrawal for the Middle East reached unsustainable levels in 2014 in the 2.6 scenario and in 2017 in the 8.5 scenario. When also accounting for the energy threshold, the actual results are from one year before for both RCPs, i.e., 2013 and 2016, respectively. The next section will present the results of a simulation that accounts for feasible withdrawal in the region.

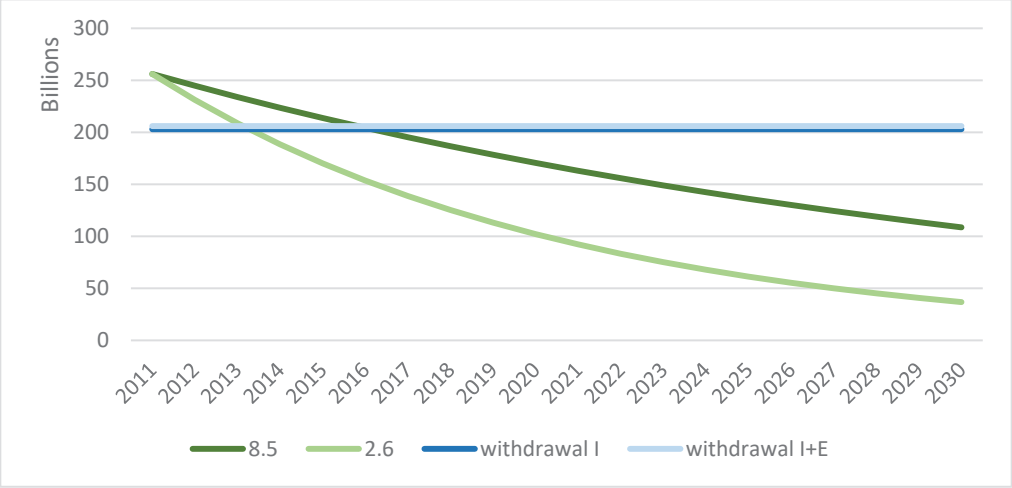

Figure 2. Water availability vs. withdrawal (two models) for the Middle East in the two RCPs (m^3/yr).

3.3. Economic Results of the Introduction of Water Climate Constraints in Middle East

The Middle East is the only significantly water-constrained region in the 2030 horizon. Therefore, the water scarcity simulation was calibrated to incorporate water withdrawal reductions that were compatible with the levels of available freshwater in the region. These simulations entailed the following impacts of sectorial output and GDP growth for the Middle East (Table 3).

Table 3. Irrigated Agriculture., energy and GDP % changes in the Middle East in three scenarios.

IRR.AG.ONLY		**Baseline**			**8.50**			**2.60**	
	Irr. Ag.	Energy	GDP	Irr. Ag.	Energy	GDP	Irr. Ag	Energy	GDP
2015	13.15	13.50	16.83	13.11	13.47	16.77	−3.84	14.12	16.51
2020	6.72	10.53	12.61	−12.01	11.84	10.14	−37.83	17.30	5.30
2025	2.73	7.73	9.65	−19.88	10.00	−0.03	−39.87	13.05	−9.15
2030	4.79	8.15	10.24	−18.17	8.83	−2.84	−38.48	8.27	−11.66
2011–2030	30.00	46.17	59.03	−34.74	51.92	24.92	−77.89	63.83	−1.54
IRR.AG + EN	Irr. Ag	Energy	GDP	Irr. Ag.	Energy	GDP	Irr. Ag.	Energy	GDP
2015	12.84	14.29	16.82	12.84	14.29	16.82	−4.30	15.04	16.58
2020	5.48	16.91	12.54	−12.57	18.53	11.63	−38.72	22.10	8.81
2025	0.70	16.51	9.66	−20.25	18.33	5.92	−41.47	18.73	0.56
2030	2.52	11.88	10.26	−18.87	12.42	4.52	−41.37	11.15	−0.69
2011–2030	22.89	74.18	58.97	−36.16	80.21	44.37	−79.88	85.38	26.69

Concerning the results of the irrigation-only model (top part of the table), the constraints of available water, as expected, had significantly negative impacts on irrigated agriculture. Significant impacts on GDP growth were also detectable, which decreased in both water-constrained scenarios with respect to the base year.

In the energy-dependent scenario, both sectors are significantly impacted by water dependency and water scarcity. Nevertheless, while agriculture and GDP follow relatively straightforward patterns—i.e., the lower output/economic growth, the more the freshwater availability is constrained—the energy sector has a peculiar behaviour. Indeed, there are two unexpected trends in the energy sector. On the one hand, the activation of the water–energy link increases sectoral production. This could be explained by the fact that the Middle East has a low water intensity in the energy sector with respect to other regions, which creates international incentives that specialise in this sector, despite the dependency on an additional factor. On the other hand, the higher the water constraint the greater the increase in energy production, even in the water-dependent model. This can also be explained by the international role that Middle East energy plays, as well as from the fact that, in a context of possible factor allocation shifts between sectors, the constrained resources are preferably redirected towards the most economically valuable sector. Accordingly, the results show a clear regional choice in shifting the available water from agriculture to energy production. Nevertheless, it is significant that this trend is not enough to guarantee the achievement of the expected baseline GDP growth, which almost halves in the worst water scarcity scenario, i.e., RCP 2.6.

4. Discussion

Water, food, and energy are strictly interrelated, and the results presented in this paper clearly signal the importance of addressing all the links between them when performing macroeconomic and climate change impact assessments. Climate-induced water constraints can be a significant threat in terms of agricultural and energetic security, as well as in terms of macroeconomic growth, even when considering the relatively short-term period of the

2030 horizon. The simulations developed in this paper show how significantly future expectations can depend on the structure of the modelling framework e.g., the presence of connections between factors and sectors. Therefore, it is crucial that we use tools that can perceive the links between the subjects of the nexus to perceive important and otherwise undetected feedback. Concerning the entity of the impacts that climate-induced freshwater availability changes can have on sectoral productivity and GDP, it is clear that, even in the short term, they are not negligible. This is particularly true for the Middle East, which is already severely water constrained, an issue that strongly affects its macroeconomic expectations and production decisions. Moreover, it appears that the connection between energy and water can lead to conclusions that are not straightforward. Indeed, instead of bringing out security issues connected to scarcity in the new energy sector, the water–energy link suggests that it would instead start to act as a resource attractor, exacerbating security issues in the agricultural sector that are already accounted for. The prioritization of energy production in the region is coherent with the regional production structure and its international role as an energy producer. Another peculiar finding can be detected in the GDP results for the Middle East. As such, while climate freshwater changes lead to a decrease in macroeconomic growth, regardless of model specifications and scenarios, the results suggest that a clear explanation of the water–energy connection reduces the overall GDP losses in the region. This is relatively counterintuitive, although it is coherent with the economic value and importance of the energy sector for the region as well as its role as international referent producer.

5. Conclusions

From the results of this paper, two conclusions can be drawn. First, from a methodological point of view, having models that can perceive the interconnections between the elements of the nexus is crucial for developing macroeconomic and climatic scenario assessments. Secondly, water, food and energy can clearly be influenced by climate change and the relative freshwater availability constraints, which can potentially hamper their provision and security. Indeed, this study showed how the expected freshwater constraint relative to different climate scenarios can significantly shape the international and domestic provision of agriculture and energy, as well as limiting the economic growth of the regions facing water scarcity, e.g., Middle East. Nevertheless, the simulations also highlight the complicated implications of the explicit connection between water and energy, especially concerning the repercussions of water scarcity in the Middle East. Indeed, the results shows that energy–water dependency does not necessarily imply losses in the new water-dependent sector. As such, energy seems to behave as a resource attractor, exacerbating security issues in the competing agricultural sector. Moreover, it suggests that GDP losses due to water scarcity could be less strong than those expected without any explicit connection between energy and water, likely due to the role of the region as an energy production hotspot, the competition/international specialization issues and its technological structure.

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Data Availability Statement: Part of the data presented in this study are openly available in SSP Public Database Version 2.0 from IIASA at DOI:10.1016/j.gloenvcha.2014.06.004 and DOI:10.1016/j.gloenvcha.2015.02.012; Part of the data are available in Inter-Sectoral Impact Model Intercomparison Project (ISIMIP) at https://doi.org/10.5880/PIK.2020.004; Part of the data presented in this study are available from the Center for Global Trade Analysis at Purdue University's Department of Agricultural Economics. Restrictions apply to the availability of these data, which were used under license for this study. A general description of the Data can be found at: https://doi.org/10.21642/JGEA.010103AF; The data that support the findings are restricted since they were produced using data under license, and so are not publicly available. Data are however available from the authors upon reasonable request and with permission of the Centro Euro-Mediterraneo sui Cambiamenti Climatici (CMCC).

Conflicts of Interest: The authors declare no conflict of interest.

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Proceeding Paper

Policy on Utilizing Indigenous Knowledge in Critical Land Rehabilitation and Fulfillment of Sustainable Food Security in Indonesia: Regrowing "Talun-Kebun" as Part of the Local Permaculture Model in West Java †

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Abstract: West Java is known as an area with high fertility rates in Indonesia; this high fertility is due to various factors, including the area's geological nature, which causes the soil to be rich in nutrients for various types of plants. Because of these conditions, West Java has historically been an agricultural area and has become a food granary. Some regions in West Java are critical buffer zones for big cities such as Jakarta. As a farming area, the people of West Java have an agricultural tradition with a pattern such as a permaculture, which is known by the local community as "talun-kebun". The "talun-kebun" is a form of shifting between cultivation and wet rice production regarding location, management, and production. Along with the massive conversion of agricultural land, the rural tradition of "talun-kebun" was later replaced by an intensive agricultural pattern using pesticides. Land conversion also caused abandoned land and abandoned agricultural areas, which have become critical land. Regarding critical land, several studies reveal that around 30% of greenhouse gas emissions that cause climate change come from land conversion and deforestation. Therefore, critical land rehabilitation is one form of effort that can be achieved in overcoming climate change. Departing from the problematic situation, this paper discusses the policies that the Government of Indonesia and the Government of West Java Province can undertake in reviving and utilizing the tradition of "talun-kebun" as a model of local permaculture to help increase food production in a sustainable manner, thus rehabilitating critical land. Using a qualitative approach through literature studies, this paper makes some policy recommendations to revive the tradition of "talun-kebun" in the West Java region.

Keywords: critical land rehabilitation; indigenous knowledge; Indonesia; local permaculture model; sustainable food security; talun-kebun; West Java

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1. Introduction

West Java Province is known as a fertile area and is one of Indonesia's primary sources of food production. In 2019, according to data from the Ministry of Agriculture, West Java Province ranked third as a rice producer in Indonesia [1]. Meanwhile, the results of Prayitno et al.'s study show that all regencies and cities in West Java Province are included in the food security category [2]. However, several indicators can cause food vulnerability, namely the high percentage of households that do not have access to clean water, low food availability in the several regencies and cities, and low life expectancy [2].

In addition, in terms of the fertility of agricultural land in West Java, according to the Head of the Agency of Food Crops and Horticulture of West Java Province, the urgent issue that requires attention is related to the restoration of soil fertility, which has decreased

a lot because of too intensive agricultural business in West Java, which is saturated with using raw materials chemically [3]. Soil fertility problems certainly have an impact on rice production. Therefore, in addition to efforts to restore land fertility, other measures such as reducing rice consumption and replacing it with other local food resources are necessary to ensure sustainable food security.

Regarding efforts to replace rice with other local food resources, a study by Hartrisari et al. shows that reducing rice consumption and replacing consumption with other carbohydrate sources will significantly impact rice sufficiency in West Java Province [4]. In addition to food resources, several studies also mention local fruit that many indigenous peoples commonly cultivate as food security alternatives. For example, in their study, Pratama et al. discussed the role of fruits in providing nutritional security and contributing to local ecosystems [5].

Use of carbohydrate food resources such as cassava and fruits as alternative food sources, as well as efforts to improve the local agricultural ecosystem, are activities related to "talun-kebun", a traditional farming practice, which although faded, is still performed in West Java. "Talun-kebun" is an upland land-use system in which annual food crops or commercial crops (kebun) alternate successively with tree crops (talun) [6]. "Talun-kebun" is one of the traditional agroforestry or permaculture systems in Java, which has been practiced for centuries [7].

Regarding "talun-kebun", the study by Christanty et al. showed how the "talun-kebun" system of bamboo growth in West Java survives on minimal external fertilizers, and how this is closely related to the growth habits and biogeochemical characteristics of the bamboo, namely rapid biomass accumulation, litter accumulation, and very high fine root biomass [6]. Referring to the study by Christanty et al., the "talun-kebun" system also has an essential role in the conservation and rehabilitation of critical land to improve the quality of local ecosystems.

The problem then is how indigenous knowledge such as "talun-kebun" can be utilized through government policies in both the Central Government and the West Java Provincial Government, so that the knowledge can be developed to improve local ecosystems, especially those related to rehabilitation of critical lands, thus meeting the need for sustainable food security. Many scholars have studied the use of indigenous knowledge to solve environmental problems, including Ajani et al. The latter studied how to use indigenous knowledge as a strategy for climate change adaptation among farmers in sub-Saharan Africa [8]. However, there are many cases of failed indigenous policies, as stated by Huencho [9]. Therefore, several things need to be considered so that the policy to encourage the utilization of "talun-kebun" can be successful.

Referring to the problematic situation, this article seeks to discuss the policies that the Government of Indonesia and the Government of West Java Province can undertake in reviving and utilizing the tradition of "talun-kebun" as a model of local permaculture to help increase food production in a sustainable and rehabilitate critical land.

2. Methods

To answer the main issues raised, this article uses a qualitative approach by searching various literature that discusses "talun-kebun" in West Java. The literature used is in the form of books, articles, reports, news, and various other documents. In addition, observations were also made on the condition of several "talun-kebun" practices that exist in several locations close to the writers' activities, namely in Megamendung Village, Megamendung Sub District, Bogor Regency (see Figure 1). This location is where the writers have been working for the last four years, and there are several agroforestry or permaculture practices.

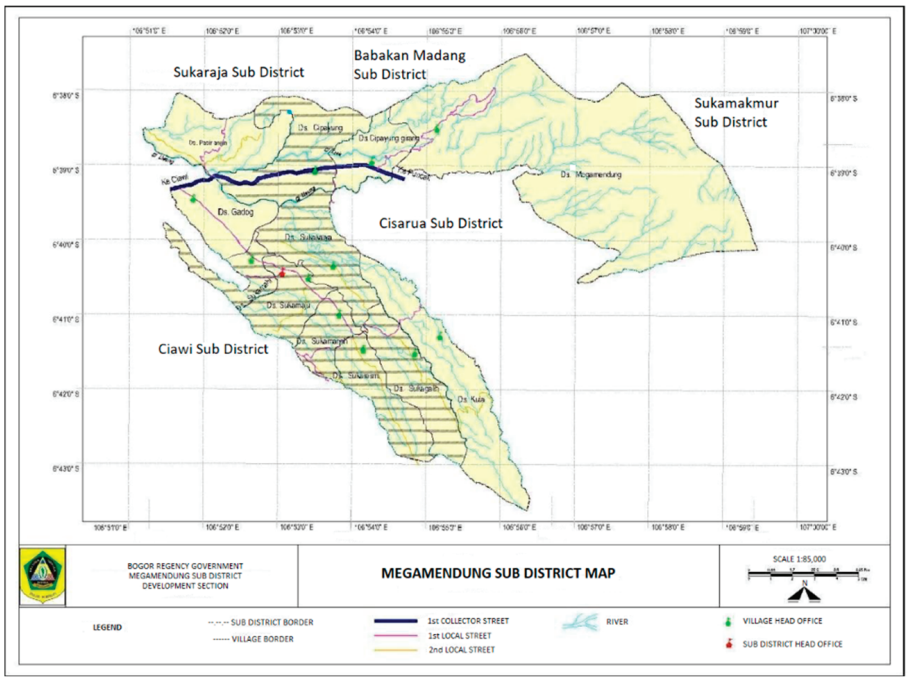

Figure 1. Megamendung Subdistrict Map.

Various data and information from several examples of the literature discussing "talun-kebun", as well as the writer's observations, were analyzed descriptively by describing and summarizing various conditions and situations that occurred in the practice of "talun-kebun". This descriptive analysis is expected to provide an overview of the potential of "talun-kebun" to be raised through several policy proposals that both the Central Government and the West Java Provincial Government can undertake. Before the analysis is outlined, the author has described the perspective of policy theory in utilizing indigenous knowledge such as "talun-kebun" and the understanding of the "talun-kebun" system itself.

3. Policy on Utilizing Indigenous Knowledge

According to Puffer, there are several reasons for the importance of indigenous knowledge. It can help to discover the best development solutions and it highlights successful people dealing with their environment [10]. Indigenous knowledge can be used to find the best solution in solving community problems; these solutions are likely to be well received because they have been practiced for a long time.

In addition, according to Subramanian and Pisupati, this traditional knowledge system continues to evolve, adapting to changing circumstances and realities, and at the same time contributing to ecological resilience [11]. Therefore, to help the community to use indigenous knowledge adequately, it is necessary to study it and place it in an appropriate position to solve various societal problems. Policies for the use of indigenous knowledge must be made and implemented adequately. For this reason, it is necessary to ensure the availability of an institutional and policy framework that supports the making of adequate indigenous knowledge utilization policies.

To ensure adequate policies in the utilization of indigenous knowledge, several challenges need to be considered and prioritized in promoting this knowledge, as stated by Gorjestani; these challenges are: encouraging the government to formulate and implement strategies for integration; increasing network capacity nationally and regionally; promoting local exchange and adaptation; and identifying innovative mechanisms for protection by encouraging further development, promotion, validation, and exchange [12]. The policies that will be made must be able to accommodate these priorities.

Meanwhile, to ensure that policies related to indigenous knowledge are successful, we also need to study why policies related to this matter fail. Huencho [9], in her study

in Chile, revealed several similarities in how various indigenous public policies in Latin America were problematic, including lack of institutional adaptation; little integration of cultural, value, historical, and social elements in policy; ignorance on the part of political actors; and lack of participation, relevance, and resources.

For the case in Chile itself, the results of Huencho's study [9] show several matters that must be considered for the policy to be successful, namely: the interdependence between policy design and policy processes and programs, and the relevance of the cultural and political dimensions of indigenous people to prevent policy failure. In terms of policy design and policy processes and programs, the implementation process has not become a space for reformulating policy, even when the policy's limitations have been stated. In addition, "power asymmetry" and "cultural asymmetry" are variables that affect the outcome; the policy will be limited if the paradigm does not change.

Regarding the relevance of the political and cultural dimensions of indigenous peoples, there are several matters that, according to Huencho [9], need to be assessed, including the need to consider the introduction of channels that allow for the active role of indigenous people, both in the policy process and as recipients; another factor to consider is reducing policymaker bias that affects indigenous people's expectations and increases distrust and delegitimacy, which in turn leads to low participation of indigenous people in decision-making, and to other impacts on misunderstanding and persistence of failure. In addition, the link between the formulation process and policy implementation also needs to be considered to reduce the occurrence of discoordination.

By referring to various opinions from experts described in the previous paragraphs, it is clear that the successful use of "talun-kebun" requires the consideration of many different matters. In particular, the consideration of how to integrate and adapt "talun-kebun" with various programs, policies, and the existing situation in the community, and how to build networks to gain broad support from multiple groups. In addition, policies must be made participatory and adaptive for various developments to be accepted and run well.

4. "Talun-Kebun" as Traditional Practices Relevant to Sustainable Development Goals

The earliest literature describing the existence of "talun-kebun" can be found in the article by Terra [13]. When discussing the Sundanese agricultural system, Terra mentions the "talun system" as a form of original agricultural system in Sunda (West Java). The talun system performs its agricultural activities by planting annual crops, generally around the village by dibble method. The talun system is usually combined with the tipar system (semi-permanent dry rice cultivation), the field system (dry rice shifting cultivation), the secondary cropping system (shifting cultivation by planting all types of annual crops and tubers after rice), and storage systems (buffalo, poultry, and goat farming). As a result of the influence of Java, the talun system was later changed to a mixed garden.

"Talun-kebun" is a form of cultivation that lies between huma and rice fields where huma is believed to represent the evolutionary basis for both "talun-kebun" and for rice, which was introduced from Central Java towards the middle of the eighteenth century [14]. On lands where rice production is impossible, communities begin to select forest plants and introduce species from other areas to obtain greater benefits, so some natural forests are gradually converted into "artificial" forests [14].

4.1. Characteristics of "Talun-Kebun"

According to Soemarwoto, "talun-kebun" is a new type of shifting cultivation whose development is based on the traditional knowledge and experience of the community, which has many positive environmental effects and offers traditional ecological wisdom [15]. "Talun-kebun" is a typical agroforestry system consisting of a mixture of perennials and annuals, giving it a structure familiar to the forest [16]. "Talun-kebun" are generally found outside the village, are rarely found inside the village, and originate from the forest through

forest species selection and introduction of new species [16]. Although it consists of many species, one or more species may be dominant in a "talun-kebun" [16].

Structurally, "talun-kebun" usually has a canopy that is layered so that it looks like a forest with annual plant species at the bottom, and with species composition differing from place to place, influenced by factors such as climate, soil, and markets [15]. "Talun-kebun", which is essentially an artificial forest, is analogous to the forest stage in shifting cultivation but provides more economic benefits to the community, where the crops are harvested and mostly sold [15]. "Talun-kebun," like forests, protect the soil from the erosive forces of rain [15].

"Talun-kebun" are private properties located on lower hillsides and are sometimes very steep. Still, erosion is minimal due to the terraced canopy structure and litter layer on the talun floor [15]. Planting is achieved by making holes in the ground with a wooden stick, into which seeds or seedlings are planted [15].

The "talun kebun" system usually consists of three stages that are functionally related and form a cycle and have different functions: (1) garden (kebun), (2) mixed garden (kebun campuran), and (3) talun, where each stage has a different function [7]. The garden (kebun) is the first stage, usually planted with a mixture of seasonal crops, and has a high economic value because most crops are sold in cash [7]. After two years, tree seedlings begin to grow in the fields. The land for annual crops is reduced so that the gardens gradually develop into mixed gardens (kebun campuran), where annual crops are mixed with half of the growing perennials, and the economic value is not as high as before, but it does have high biophysical value because it promotes soil and water conservation [7]. After the annual harvest, the fields are usually left for two to three years to dominate perennials. This stage is known as talun and has economic and biophysical value [7].

4.2. Type of "Talun-Kebun"

According to Christanty et al., based on the dominant type, talun in West Java can be divided into three types: wood lot (dominated by a mixture of firewood and wood species); permanent mixed talun (dominated by a mix of fruit trees and annual commercial crops); and talun bamboo (the best example of a "talun-kebun" rotation cycle, dominated by bamboo species with trees scattered among bamboo clumps) [6]. In terms of types of plants, the results of Suharjito's research suggest several main reasons for "talun-kebun" farmers when choosing plant types, namely: plants that produce a great or maximum yield; crops that produce different results; easy-to-maintain plants; marketable plants; and crops whose prices are stable or rising [17].

4.3. Function of "Talun-Kebun"

There are several functions of the "talun-kebun", which are as follows:

1. Economic and social function, because the crops can be sold and have a high selling value, and they also meet the farmer's own needs. Moreover, landless and poor farmers are allowed to take fallen branches and twigs or cut down dead wood for firewood and are employed at harvest time [16];
2. Soil conservation and sustainability, because soil erosion in the "talun-kebun" is minimal because it has well-developed hydrological and erosion control functions [16];
3. "Talun-kebun" is also a genetic resource due to its high multispecies composition with several wild or semi-wild species [15].

4.4. The Relevance of "Talun-Kebun" to the Sustainable Development Goals

If the "talun-kebun" is associated with the 17 Sustainable Development Goals [18], then, in the author's view, it is related to the following five goals, namely:

- Goal 1: No poverty. "Talun-kebun" can contribute to the achievement of the no poverty goal. Referring to Soemarwoto and Soemarwoto [16], the results of the "talun-kebun" system have a high enough income potential, resulting in the potential to contribute to poverty eradication efforts;

- Goal 2: Zero hunger. "Talun kebun" can contribute to the achievement of zero hunger's goals. In the "talun-kebun" system, various food crops, both those containing carbohydrates and multiple types of fruit and other food crops, are grown. The harvest from "talun-kebun" is also used to fulfill family needs other than for sale so that it can also contribute to fulfilling food security;
- Goal 5: Gender equality. Referring to the findings of Mizuno et al. [19], the principle of gender equality is still alive and well. From the perspective of land tenure and labor allocation, the contribution of women is clear. In many cases, the land owned by the wife is more significant than that owned by the husband and the labor allocated by the women. Therefore the "talun kebun" system can contribute to achieving the goals of gender equality;
- Goal 13: Climate action. Various plants grown in the "talun-kebun" system will, of course, have a significant contribution to absorbing CO2 so that they can contribute to efforts to overcome climate change;
- Goal 15: Life on land. The "talun-kebun" system has several functions, including those related to genetic resources by looking at the biodiversity of the various plants grown and the different types of animals and insects that live in their ecosystems, apart from their ability to conserve soil and rehabilitate critical lands. Therefore, the "talun-kebun" system can contribute to achieving the goal of life on land.

5. Discussion: The Current Condition of "Talun-Kebun" and Possible Policy Directions

By using various literature sources and limited observations in the Megamendung Village area where the authors live, this section attempts to describe the condition of "talun-kebun" and the policy directions that can be taken to utilize this practice. This section consists of two parts, namely the current conditions of the practice of "talun-kebun" in West Java and policy directions that can be undertaken.

5.1. The Current Condition of the "Talun-Kebun" Practice

Referring to several pieces of the literature, the "talun-kebun" system is still practiced today. Iskandar, for example, revealed that the "talun-kebun" system is still widely practiced by the Sundanese people [20].

The practice of "talun-kebun" can be found, for example, in several indigenous communities. Suganda, in his writings, for example, describes the practice of "talun-kebun" performed by the indigenous community of Kasepuhan Ciptagelar [21]. The "talun-kebun" practiced by the indigenous people of Kasepuhan Ciptagelar usually consists of gardens of wood, vegetables, fruits, and other horticulture [21]. "Talun-kebun" is a source of timber needs from the Kasepuhan Ciptagelar indigenous people so that they do not need to take from the forest for their timber needs. Therefore, the forest around the community's location can be maintained [21].

Regarding the "talun-kebun" in the Kasepuhan Ciptagelar indigenous community, Kodir, in his research, stated the high diversity and richness of plant species [22]. In addition, by referring to the potential data of Kasepuhan Ciptagelar in 2008 cited in Kodir's research, it is known that the area of "talun-kebun" in this indigenous community is 35 hectares or 17.33% of the total land-use area of 202 hectares [22]. This condition is in line with the research by Christanty et al. in 1986, which stated that the use of "talun-kebun" land in West Java was 16% [7].

Soemarwoto [15] stated that the "talun kebun" system is usually private or communal property. Related to this, according to Winarti in her research, citing various sources, the average land area owned for "talun-kebun" is around 400 square meters to 1.2 hectares [23]. Based on the observations made by the authors regarding ownership and control of land by farmers around the location of the author's activity, most of the farmers are cultivators on state land or work on other people's land with a profit-sharing system. Regarding farmers who work on other people's land, the research of Inoue et al. revealed that private land owned by others could be a safety net for a small number of people or farmers who

have access to the land [24]. Or, in other words, who cooperate or are given access by the landowner.

Seeing a situation like this and based on observations made, in several locations where there is a lot of abandoned land in the sense that it is owned by someone (usually not living in the area) but is not being used, it is possible to seek a pattern of cooperation or provide access to farmers who do not have land with a "talun-kebun" system. Therefore, the abandoned land can provide benefits both economically and to the environment.

In addition to the aspect of land ownership, gender equality is also a matter that requires attention. Although, as Mizuno et al. highlighted, the principle of gender equality is still alive and well in the "talun-kebun" system [19], there are still disparities. The wife's wider land ownership compared to her husband still creates a gender bias in the perspective of food allocation. In terms of food intake (energy and protein) and protein adequacy, the level obtained by women always remains lower than men [19]. In line with this condition, Wiyanti's research found that although women have a significant role and contribution in "talun-kebun," the decision-making in the "talun-kebun" system is still dominated by men, where women can give advice. Still, the final decision remains on the male side [25].

Another problem that needs to be considered is the change of "talun-kebun" into a commercial garden with a monoculture system to eliminate the multi-functions that have been the peculiarity of "talun-kebun," which are not only economic but also social and conservational. The problem of converting "talun-kebun" into a commercial garden has also been identified by Chrisanty et al. [7] and stated by Kimmins et al. [26] and Iskandar [20]. This situation, of course, needs to be assessed by considering the multifunctionality of "talun-kebun," which has many benefits, especially in terms of conservation.

The conversion of "talun-kebun" into a commercial garden, in the author's view, can also be caused by the pattern of its development where, in the third phase, mixed gardens turn into talun, and their utilization is limited only to the utilization of their wood products. Related to this, it is necessary to consider that during the mixed garden phase (after the garden phase), the plants that must be planted are plants such as fruits, so that when the gardens enter the talun phase, they can still produce fruits that can be consumed or sold. In other words, in the authors' view, the consideration should be of how to direct the talun into a food forest. Therefore, in this effort to develop "talun-kebun", farmers also need support to run the plants in their "talun-kebun" so that it becomes a food forest.

5.2. Policy Directions to Utilize "Talun-Kebun"

By considering several problems encountered in the implementation of the "talun-kebun" system, there are several policy directions that can be considered by the Central and West Java Provincial Governments to be able to utilize them so that they can contribute both to conservation and food security, as described below:

- Ensure that the existing practice of "talun-kebun" can be maintained because it is proven to have an essential function for food security, economy, social, and environmental conservation. To minimize the shift in the function of "talun-kebun," farmers also need to gain support from both central and regional governments in running "talun-kebun" to be directed to plant types of plants that can become food forests. In addition, farmers also need to be assisted by both central and regional governments in terms of marketing their harvests so that they can provide better economic potential;
- For "talun-kebun" to develop and to conserve the environment of abandoned land, the government can seek to provide access to farmers who do not own land so that they can take advantage of abandoned land; this can be achieved by providing incentives and disincentives for the owners or rulers of abandoned land so that they are willing to give access to the use of abandoned land for "talun-kebun" activities. In addition, the social forestry program that is currently being promoted is more focused on management with the "talun-kebun" system compared to monoculture;

- To strengthen gender equality, efforts are needed to improve women's skills, especially in providing added value to post-harvest products so that they can enhance their household economy;
- Promoting the "talun-kebun" system to gain the community's attention and expand its support network in various circles of society.

6. Concluding Remarks

In summary, it can be concluded that "talun-kebun" is a traditional practice that needs to be maintained and developed because it has various functions that can support food security, economy, social matters, and conservation. For this reason, the government needs to consider several matters in this effort, including encouraging "talun-kebun" towards a food forest so that the harvest after becoming talun can still be economically promising. In addition, it is important to consider how to ensure better access to the use of abandoned land and how to increase women's skills in post-harvest management and promotion of the vital function of "talun-kebun". A more in-depth study is needed to provide an adequate basis for the government to make optimal policies in the effort to utilize "talun-kebun".

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Proceeding Paper

Household Poverty Status and Willingness to Pay for Renewable Energy Technologies: Evidence from Southwestern Nigeria †

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Abstract: This study examined households' poverty status and willingness to pay for renewable energy technologies (RETs) in Southwestern Nigeria. Three hundred and four households in Southwestern Nigeria were surveyed. Households were grouped into poor and non-poor using two-thirds of the mean per capita expenditure (MPCE), and poverty depth and severity were calculated using the Foster–Greer–Thorbecke (FGT) poverty measure. The poverty line (two-thirds of the MPCE) for the households was calculated to be ₦80,412.57 and the poverty depth 0.0827. The results of Heckman's two-stage model revealed that age, marital status, level of education, household size, house location, income and awareness about RETs are factors influencing surveyed households' WTP and payout levels for RETs.

Keywords: willingness to pay; renewable energy; contingent valuation method; foster greer thorbecke; mean per capita expenditure

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1. Introduction

Energy is crucial in all human endeavours, such that the growth and development of any economy are hinged on it. People need energy for various purposes including lighting, cooking, transportation and even entertainment. In the quest to meet their essential energy needs, individuals, households and businesses resort to various means. Recently, a series of events ranging from severe changes in atmospheric weather, bushfires, droughts and other events have been consequences of the changing climate [1]. Climate change is a global menace that has received attention from the majority of world economies. While there are natural causes, the anthropogenic causes of climate change are more significant. These sources largely consist of the burning of fossil fuels to meet the energy demands of the growing global population. Apart from resource depletion and damage to the natural environment associated with the burning of non-renewable fuels, serious health complications and issues have been reported arising from the inhalation of fumes from fuel combustion. This has increased the mortality rate especially in countries with developing economies that have low-quality health facilities to treat the resultant illnesses.

Many countries have recorded considerable success in substituting fossil fuels with renewable sources [2,3]. However, the situation is worrisome in certain developing countries such as Nigeria. Despite the country's advantages in RETs, such as abundant solar radiation to power solar photovoltaic cells, high winds to drive wind turbines and water sources to

explore hydropower, RET uptake has been low. Although the initial investment in RET can be huge for projects such as solar power systems; there has been a lack of evidence in the case of Nigeria to ascertain the factors limiting the uptake of RETs. Hence, the primary objective of this study is to investigate household poverty status and willingness to pay (WTP) for renewable energy technologies, using Nigeria as a case study.

2. Literature Review

2.1. Theory of Consumer Behaviour

This study is hinged on the theory of consumer behaviour. The theory states that a rational consumer seeks to maximise his level of utility in the consumption of goods given his budget constraints. Contextually, other factors being constant, a household willing to pay for renewable energy technology think that they are better off with its usage and vice versa [4,5]. CVM has been deemed appropriate for estimating levels of customer satisfaction especially for public goods and goods with limited private nature.

2.2. WTP—Contingent Valuation Method

The contingent valuation method seeks to create a non-existent marketplace for non-market goods, to allow measurement of people's willingness to pay (WTP) for the use of the goods or their willingness to accept (WTA) deprivation of the benefits arising from the goods due to inability to use them. While the method is also applicable for the valuation of marketable goods which are readily available in marketplaces, its application is largely seen in studying public goods including air and water quality improvements. CVM has been particularly useful when complemented by other techniques used in valuing non-market goods, such as hedonic and travel–cost approaches. Hence, the primary goal of the contingent valuation is to determine the compensating variation for the item being assessed, in this case, renewable energy technologies [6–8].

2.3. Empirical Review on Household Poverty, WTP and Renewable Energy Use

Several studies have documented the relationship between household poverty status proxied by income and WTP for renewable energies. According to the studies conducted by [9,10], income plays a significant role in a household's decision to adopt RETs and high WTP for electricity from renewable sources is common with high-income earners. Also, educational attainment directly influences WTP for energy services. Hence, highly educated individuals have a higher willingness to pay than their counterparts [10]. In previous analysis [11], age and gender were shown to have a mixed relationship with WTP for renewable energy while other studies [12,13] indicated that age, altruism, awareness and concerns for environmental issues not only affect household demand for renewable energy but also WTP for it. These previous findings suggest that socio-economic factors influence consumers' WTP for RETs.

3. Methodology

3.1. Sampling Method and Data Collection Technique

The three hundred and four samples were recruited by convenience sampling. This was necessary due to the COVID-19 pandemic at the time this study was conducted, making face-to-face data collection impossible. Online questionnaires were sent to participants and follow-up questions were also presented to test the veracity of their responses. About four hundred responses were received, of which only three hundred and four were complete and had the required variables for analysis after cleaning. Although the sample may not be entirely representative of the population due to its limitations, it gives an indication of the situation in the country.

3.2. Foster–Greer–Thorbecke (FGT) Poverty Measure

The Foster–Greer–Thorbecke (FGT) poverty measure was used in this study to determine poverty status among households in the study region. According to the literature [14], the model is as follows:

$$P_\alpha = {}^1/_n \sum_{i=1}^{h} (Z - Y_i/Z) \quad (1)$$

where:

Y_1 is the expenditure per household head equivalent of ith household, Z is the poverty line, n is the number of households; h is the number of the sampled population below the poverty line and α is an aversion to poverty, a coefficient reflecting different degrees of importance according to the depth or severity of poverty. A poverty threshold was obtained using two-thirds of the mean consumption per adult equivalent in the households. This threshold was used to separate poor households from the non-poor. The headcount index (P_0) measures the proportion of the population that is food poor; the poverty gap index (P_1) measures the extent to which individuals fall below the poverty line as a proportion of the poverty line; the squared poverty gap (P_2) is poverty severity, which averages the squares of the poverty gaps relative to the poverty line.

3.3. Contingent Valuation Method

According to the literature [15], the contingent valuation technique is a simple and adaptable non-market approach, often known as the expressed preference model. According to researchers [16], it is widely used for cost-benefit analyses and environmental impact evaluations of non-market resources. This approach, however, was used to determine the value of renewable energy and other non-market resources [17] as it allows for a direct evaluation of WTP. Consumers were explicitly requested to indicate their WTP for RETs using this technique. The contingency valuation method (CVM) is mathematically stated as follows:

$$WTP_i = \sum_{hi=1}^{T_i} \delta h_i \, Ph_i \quad (2)$$

where: WTP_i represents the average payout level of households in the region I; δh_i represents the payout level for a household's h_i; Ph_i represents the frequency of the payment value of a household's h_i; and T_i represents the number of samples from the surveyed population.

3.4. Heckman's Two-Stage Model

Heckman's two-stage model was devised by James Heckman, who received the Nobel Prize in Economics in 2000 for the concept [18]. Heckman's two-stage approach may successfully rectify the selectivity deviation, which is a one-of-a-kind problem [19]. Furthermore, this model can be used to examine the factors influencing households' WTP and payout level [20].

Model selection: The renewable energy technologies payment activities of households studied in this paper were divided into two stages. The first stage is the behavioural decision stage when households decide whether to pay for RETs. Households who do not have the willingness to pay were not carried forward to the next phase of the study, and the households who had the willingness to pay entered the second stage. The second stage is the payout level of the decision-making stage, which refers to the payout level of the households who are willing to pay for RETs. Hence, this paper employed Heckman's two-stage model to analyze the factors influencing households' WTP and their payout level, respectively. The model is expressed as follows and contains the two-stage models Model 1 and Model 2.

Model 1 is a Probit model, which mainly examined the impacting factors for households who are willing to pay for RET. Following [21], the specific model is shown below:

$$E\left(\frac{Y}{M}\right) = \mathrm{P}(Y = 1/M) = \Phi(\mu_0 + \mu_1 M) = \mu_0 + \mu_1 M_1 + \mu_2 M_2 + \mu_3 M_3 + - - - - - - - - + \mu_n M_n + \theta \quad (3)$$

where:

Y is the endogenous variable while M_n are the exogenous variables.
Y = WTP for RETs (Yes = 1, No = 0)
M_1 = Age in years
M_2 = Gender (Male = 1, female = 2)
M_3 = Educational level (Secondary = 1, Tertiary s= 2)
M_4 = Household size in numbers
M_5 = Marital status (Single = 1, Married = 2)
M_6 = Awareness about RETs (Yes = 1, No = 0)
M_7 = Monthly income in Naira
μ = Parameter estimate
θ = error term

Model 2 is a multiple linear regression model, which mainly examined the factors influencing the households' payout level. According to the literature [22], the implicit model is expressed as:

$$T = \varphi_0 + \varphi_1 M_1 + \varphi_2 M_2 + \varphi_3 M_3 + - - - - + \varphi_n M_n + \varepsilon\lambda + \delta \ldots\ldots\ldots\ldots\ldots \quad (4)$$

where:

T is the endogenous variable while Ms are the exogenous variables.
T = Payout level in Naira
M_1 = Age in years
M_2 = Gender (Male = 1, female = 2)
M_3 = Educational level (Secondary = 1, Tertiary = 2)
M_4 = Household size in numbers
M_5 = Household location (Rural = 1, Urban = 2, Peri-urban = 3)
M_6 = Marital status (Single = 1, Married = 2)
M_7 = Monthly income in Naira
φ = Parameter estimate
δ = error term

4. Results and Discussions

This section is divided into three parts. First, we report the socio-economic characteristics of respondents in the Southwestern part of Nigeria. The second part concentrates on their poverty status and WTP for renewable energy services. Lastly, we examine the factors influencing a household's willingness to pay for RETs.

4.1. Sample Characteristics

In Table 1, the descriptive statistics of the socioeconomic characteristics of the surveyed households in Southwestern Nigeria are profiled. The results revealed that most of the respondents are young, with a mean age of 29 $\pm$ 7 years. This indicates that the surveyed households have young household heads, which has many economic implications. About 54 per cent of the sampled households were headed by a female which contradicted previous findings [23,24] reporting that male-headed households dominate the Nigerian population. This result may be attributed to the limitations of the study which adopted a convenient sampling method through online means. The findings relating to average years spent in formal education show that the majority (about 97 per cent) of respondents have tertiary education. As indicated in Table 1, the average household size was 5 members per household, which is similar to the figures reported in a previous study [24]. About three-quarters of the sampled population were married while only one-quarter were single.

Table 1. Socio-economic characteristics of households in the region.

Variable	Description	Southwestern Nigeria (n = 304)
Age	Age of household head (years)	28.62 (6.77)
Gender	Gender of household head (1 = Male, 2 = Female)	1.54 (0.50)
Educational level	Level of education of respondent (Secondary = 1, Tertiary = 2)	1.97 (0.16)
Household size	Number of household members	5.37 (2.35)
Occupation	Primary occupation of respondents (Civil service = 1, Farming = 2, Trading = 3, Others = 4)	2.72 (0.88)
Marital status	Marital status of respondents (Single = 1, Married = 2)	1.73 (0.44)
Social group	Respondents belong to a social group like cooperative societies (Yes = 1, No = 2)	1.26 (0.44)
Household location	The location of the household of respondents (Rural = 1, Urban = 2, Peri-urban = 3)	2.51 (0.80)

Source: Authors' Survey, 2021.

4.2. Household's Monthly Expenditures

Table 2 presents the household's average monthly expenditure on food, non-food and energy. Of the three items, households expend the least amount on energy while the highest expenditure is on food items. The distribution of households' income on these items with the highest expenditure given to food is reasonable given that many have opined that food is the most important of the three basic needs of man—food, clothing and shelter. Although the maximum amount spent by a particular household on non-food items was the highest of the three categories of needs, the lowest amount spent on these items revealed that households place a higher premium on food.

Table 2. Distribution of Household's Average Monthly Expenditure in Naira.

Item	Mean	Std. Dev.	Min	Max.
Food	66,513.16	61,462.48	10,000	800,000
Non-Food	53,505.59	80,184.31	800	890,900
Energy	17,693.13	22,899.74	600	300,000

Source: Field Survey, 2021.

4.3. The Poverty Line

In constructing the poverty line, two-thirds of the mean per capita expenditure (MPCE) was used. The MPCE was calculated as the summation of households' total expenditure on food and non-food items divided by the sample size as shown in Table 3. Following this process, ₦80,412.57 was determined as the poverty line such that households living below this value per month were categorised as being poor, and non-poor if otherwise, as shown in Table 4. However, this value is higher than was reported in a previous study [24] carried out in the Southwestern region. This can be attributed to the nature of the two studies; the earlier study [24] considered the food security status of households and thus used only food expenditure, whereas the current study considered expenditure on both food and non-food items.

Table 3. Mean per Capita Expenditure and Poverty Line.

Estimate	Food	Non-Food	Total
Total expenditure	20,220,000	16,265,700	36,485,700
Mean per capita expenditure (MPCE)	66,513.16	53,505.59	120,018.75
Two-third of the MCPE	44,563.82	35,848.75	80,412.57

Source: Field Survey, 2021.

Table 4. Households' Poverty Headcount, Gap and Severity.

Poverty Status	Estimate	Poverty Line
Head count P_0	0.2993	80,412.57
Poverty gap P_1	0.0827	80,412.57
Poverty severity P_2	0.0351	80,412.57

4.4. Household's Poverty Status

Table 5 presents the distribution of households into poor and non-poor following the analysis above. About 30 per cent of the households in the region are poor. This implies that these households spend below ₦80,412.57 on food and non-food items per month. This result is similar to reports [24,25] that more households in the region are food secure than are food insecure.

Table 5. Distribution of Household's Poverty Status.

Poverty Status	Frequency	Percentage
Poor	91	29.93
Non-Poor	213	70.07
Total	304	100.00

Authors' Survey, 2021.

4.5. Poverty Headcount, Gap and Severity

The poverty incidence shown by the headcount in Table 4 shows that 29.9 per cent of the sampled households are poor. By indication, these are the households whose monthly spending falls below the poverty line of ₦80,412.57. The poverty gap of 0.082 shows that households in the region that are poor will need to raise their monthly expenditure by 8.2 per cent to reach the poverty line. However, poverty severity in the region is very low at 3.5 per cent.

4.6. Reasons for Households' Lack of Usage of Renewable Energy in the Study Area

Table 6 presents the reasons highlighted by households for their lack of usage of renewable energy. The high set-up costs of solar, hydro and portable wind turbines in the region are the most important reasons why households have not embraced renewable energy technologies. Of the sampled households, 83.55 per cent lack knowledge about renewable energies. Almost 60 per cent of the households highlighted the intermittent supply of power from renewable sources as a reason for continuing to use non-renewable sources. While this problem of intermittent power supply from wind and sun has been reported in the literature [2], experts have shown that renewable energies can still meet daily energy needs. The fact that RETs are not common in the region was not highlighted as a major reason for the low uptake.

Table 6. Reasons for Households' Lack of Usage of Renewable Energy.

Reasons	Percentage	Rank
High installation cost	91.45	1
Lack of knowledge	83.55	2
High maintenance cost	76.97	3
Intermittent supply	57.57	4
Not common in the locality	28.62	5

4.7. Factors Influencing Households' WTP for RETs

Table 7 shows the estimated results of the factors influencing households' WTP for RETs. The variance inflation factor enabled us to check for multicollinearity among the dependent variables. Hence, all the variables in the model passed the minimum requirement for inclusion in the analysis. The results in Table 7 show a Pseudo R^2 of 0.2627 implying that the model is of good fit, which is further strengthened by the Likelihood Ratio (LR) test statistic of 4.78 significant at 1 per cent. Using these estimates, we accept the alternative hypothesis that the joint effect of all the explanatory variables has a significant effect on a household's WTP for RETs.

Table 7. Estimates of the Factors Influencing WTP for RETs.

Variable	Coefficient	Standard Error	*P* > /z/
Constant	1.8615	1.0223	0.069
Age	0.0503 ***	0.0017	0.000
Gender	−0.2843	1.9511	0.884
Marital status	0.8300 *	0.4833	0.086
Income	0.0044 ***	0.0014	0.003
Level of education	0.0699 **	0.0298	0.019
Household size	0.7896 ***	0.1497	0.000
Awareness	0.2283 ***	0.0237	0.000
LR Chi^2	4.78		
Prob Chi^2	0.0001		
Pseudo R^2	0.2627		

The asterisks (*, **, ***) denote a statistically significant level at 10%, 5% and 1% respectively.

The coefficient of age is positive and significant at 1 per cent. This implies that older household heads have a higher likelihood of being willing to pay for RETs. As many health issues are associated with old age, they will be willing to pay more for RETs which are cleaner energy sources than conventional sources such as firewood. Conventional sources of energy have been reported to have serious health implications through inhalation of fumes during combustion. Marital status is positive and significant at 10 per cent. Thus, married household heads have a higher likelihood of being willing to pay for RETs than single counterparts. This may largely be attributed to the shared responsibilities which come with marriage. The coefficient of monthly income is positive and significant at 1 per cent. Income is an indicator of purchasing power and thus, higher-income earners have higher purchasing power. The direct relationship between income and WTP has been reported by several authors in the literature [7,26]. Household size is positive and significant at 10 per cent. The positive relationship is contrary to previous reports [7] suggesting that because of the attendant cost of meeting other basic needs of a larger household, WTP for new or improved energy sources or RETs will not be a priority. Awareness of RETs is also significant at 1 per cent. Knowledge and awareness of modern RETs is vital for improving their uptake. WTP increases when households become more aware of the benefits of using the new technologies as opposed to the conventional technologies.

4.8. Factors Influencing the Amount Households Are Willing to Pay for RETs

Table 8 shows the estimated results of the factors influencing the amount households are willing to pay for RETs. The R^2 value of 0.5150 implies that about 52 per cent of the

variation in the dependent variable is explained by the explanatory variables included in the model. The P>F value is significant at 1 per cent, which shows that the model is a good fit. Using these estimates, we accept the alternative hypothesis that the joint effect of all the explanatory variables has a significant effect on the amount households are willing to pay for RETs.

Table 8. OLS Estimates of the Factors Influencing the Amount Willing to Pay for RETs.

Variable	Coefficient	Standard Error	*p*-Value
Constant	0.1637	0.13825	0.237
Age	0.5576 **	0.2799	0.048
Marital status	10.3134 ***	0.7230	0.000
Level of education	0.1428 ***	0.4361	0.001
Household size	0.5063 ***	0.1325	0.000
House location	0.5509 *	0.4022	0.082
Income	0.6421 **	0.2818	0.024
Gender	0.1226	0.2459	0.619
R-squared	0.5160		
Adj. R^2	0.5030		
RMSE	4.8279		
$P > F$	0.0000		

The asterisks (*, **, ***) denote a statistically significant level at 10%, 5% and 1% respectively.

The result shows that age, marital status, level of education, household size, location and income are positive and significant at different levels. The coefficient of age is significant at 5 per cent, which implies that an increase in age by one year will increase the amount households are willing to pay for RETs by 0.56. The coefficient of the level of education is significant at 1 per cent. This shows that household heads with higher levels of education are willing to pay more for RETs. This is in tandem with other findings [23] reporting that higher educational status predisposes households to higher income, so they can easily afford basic needs especially as these relate to improved quality of life. Marital status is significant at 1 per cent, which implies that married household heads are willing to pay a higher amount for RETs. This may be because of an increase in the sources of income available to the household. The coefficient of monthly income is significant at 5 per cent. Because income is an indicator of purchasing power, an increase in monthly income increases the amount households are willing to pay for RETs. The location of the household is significant at 1 per cent, which indicates that households in urban and peri-urban centres are willing to pay more for RETs. However, household size is positive and significant at 1 per cent, contrary to previous findings [23] that household size is negatively related to household poverty status. However, the positive relationship between the amount willing to pay and household size can be attributed to additional benefits (which may be in form of finance) available to the household by having an additional family member especially one that is gainfully employed.

5. Conclusions

This study examined household poverty status and willingness to pay for renewable energy technology, using evidence from Southwestern Nigeria in the form of primary data collected from 304 households using online means. Despite the popularity and improved uptake of renewable energy technologies in developed economies, Nigeria still lags behind in this respect. Low levels of income and high poverty levels have been reported as possible causes of this. In this study, age, marital status, level of education, household size, house location, income and awareness about RETs have all been shown to influence WTP and the amount that households are willing to pay for modern RETs. However, level of education is the most influential predictor. Based on the findings of this study, it is recommended that the government and other concerned stakeholders should invest in educating the public about the national and global benefits of transitioning to renewable energies in an atempt to mitigate the impact of climate change. This study was limited in the way the

data was collected. The questionnaire was administered through various social media channels mainly because of COVID-19 in the study area and the high cost of administering the questionnaire. Thus, no proper sampling could be undertaken. However, the data was thoroughly cleaned before analysis was carried out.

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Proceeding Paper

Climate Technology Readiness Assessment, an ESG-Based Resource Allocation Methodology in Ports: A Case in the Hellenic Republic Asset Development Fund †

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Abstract: The Hellenic Republic Asset Development Fund (HRADF) has identified a methodology with the potential to enhance resource allocation within the framework of climate technology investment. The methodology was conceptualized and tested as part of implementing the HRADF's ESG rating tool in the ports included in the HRADF's portfolio. The methodology aims to assess the readiness of ports to adopt climate technologies that are essential to support action to reduce greenhouse gas emissions and adapt to the adverse effects of climate change and consequently mitigate the environmental and social impacts on coastal locations and neighbouring communities. It entails the addition of "Climate Technology" key performance indicators (CT-KPIs) to the underlying questionnaire of the HRADF ESG rating tool. After ports had shared their answers in response to the expanded ESG rating tool, the sustainability team at HRADF performed a thematic analysis. The resulting analysis sheds light on the different forces shaping the organisational readiness of ports. Some of these forces are inherent to the port's management (e.g., organisational structure), while others are shaped by the evolving landscape associated with disclosure standards. A standardised set of CT-KPIs may benefit port authorities, since they demonstrate compliance and commitment to continuous improvement through scientific evidence and quantifiable organisational measures. Their climate technology readiness can be tracked, and appropriate measures can be defined and therefore help port administrators to unlock additional funding sources and attract international financial institutions' support. In addition, investors increasingly recognize that climate risk is an investment risk and ask for more detailed climate-related disclosure. One of the main contributions of this methodology is that it can allow investors, regulators, and other decision-makers to recognise climate related risks and opportunities and prioritise resource allocation, which is paramount for the achievement of climate targets and a successful pandemic recovery strategy.

Keywords: climate technology readiness; cleantech; green technologies; environmental technology; ESG; green ports; sustainable investments; digital ESG tools

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1. Introduction

The Hellenic Republic Asset Development Fund (hereunder "HRADF" or "Fund") was established in 2011 (founding Law No. 3986/2011 [1]) and promotes and implements the Hellenic Republic's asset development programme, with the vision to achieve the following:

- Deliver long term, sustainable and investor-friendly asset developments that are socially acceptable;
- Create new job opportunities;
- Help restructure markets to the benefit of end consumers, always ensuring value accretion to all stakeholders.

The duration of HRADF is until 1 July 2026. Its sole shareholder is the Hellenic Corporation of Assets and Participations (HCAP). HRADF manages part of the state's private property to maximise its value and contributes largely to public debt reduction by attracting direct investments through the implementation of the Asset Development Plan (ADP) [2], which is updated on a six-month basis. The portfolio of assets entrusted to HRADF to facilitate its development plan is diverse. It includes companies' shares, infrastructure assets, and real estate in the most competitive market categories (energy, transport, tourism, etc.). In addition, HRADF holds 100% of shares in 10 port authorities [3], which have the right to operate the respective ports until 2042.

In addition, Law 4799/2021 [4] provided for the possibility of assigning to HRADF the maturation of contracts that are part of the Development Programme for Contracts of Strategic Importance, and with the recent law 4804/2021 [5], the purpose of HRADF was expanded, to include the provision of maturation services through a discrete operational unit at HRADF (Project Preparation Facility/PPF), maximizing amongst others the impact of EU Recovery and Resilience Facility, from 2021 onwards. According to this law, in pursuing the purpose of the Fund, particular care shall be taken to contribute to achieving the objectives of the European Green Deal and the 17 Sustainable Development Goals (SDGs) of the United Nations.

Greece itself is committed to sustainable development and supports the long-term strategic vision by 2050 of a European economy that does not burden the climate. In this context, HRADF can be a driving force of Greece towards achieving Sustainable Development by integrating sustainability principles throughout HRADF's value creation process while supporting HRADF strategic objectives. One recent development towards that direction is that the latest updated ADP of the Fund, which was approved by the Government Council for Economic Policy (KYSOIP) on 13/5/2021, includes for the first time guidelines for the incorporation of the principles of sustainability and the adoption of ESG (Environmental, Social and Corporate Governance) criteria during the implementation of the Fund's programme, thereby reinforcing the attraction of responsible investments to the benefit of the Greek economy and society, contributing at the same time towards achieving the national energy and climate goals.

The development of the private property of the Hellenic Republic has been a critical pillar of the effort to correct the structural problems and macroeconomic imbalances that had led Greece to the profound social and economic crisis of the last decade. The economic impact of the Fund's programme is expected to be multi-dimensional, going far beyond the revenues from the sale transaction. According to IOBE, 2020 [6], HRADF's programme is shown to have had a strong positive impact on the Greek economy, with clear social benefits during a challenging period for the country. For the overall programme, it is estimated to have boosted the country's GDP by around EUR 1 bn a year on average over the period 2011–2019, with the benefits for the economy estimated to have exceeded EUR 20 billion. Over the same period, the average impact on employment was close to 20,000 full-time jobs. In addition, the HRADF's programme brings significant improvements and interventions in the regulatory framework and investment commitments, which have stimulated economic activity and increased the efficiency of the production factors during a challenging period for Greece. Finally, the international investor community has seen HRADF's programme progress as evidence of the state's commitment to reform the Greek economy.

As a country thirsting for investment and seeking to shift its development model to a more sustainable path, Greece should take advantage of the opportunities offered by the global market trend for green projects and use innovative financing tools that will facilitate the flow of capital into sustainable investments. Sustainability at HRADF aims at leveraging HRADF's position at the intersection of investment, sustainability, and regulation to streamline sustainable investment in Greece.

To that end, HRADF first developed the digital ESG Rating tool [7] in cooperation with European Bank for Reconstruction and Development (EBRD) and Global Sustain. Subsequently, the Fund's sustainability team modified it to include KPIs that will support

the assessment of the readiness of its portfolio companies to adopt climate technologies. HRADF began deploying the modified tool with the fund's portfolio of ports. The methodology was intended to deliver a service that would improve information transparency and communication between investors and entrepreneurs, accelerate technology readiness of ports and ultimately enhance their climate resilience that, according to UNCTAD, 2020 [8], "is a matter of strategic economic importance and key in achieving progress on many of the Goals and targets under the 2030 Agenda for Sustainable Development".

2. Background

Infrastructure and transport are among the sectors most exposed to climate change. Moreover, they are critical to national economic performance, growth and development. Ports in particular play a vital role in the world economy. More than 80% of goods traded worldwide are transported by sea and through ports. Climate risks analyses and subsequent climate-proofing need to be incorporated as key features, given that the potential impact of climate change on ports will have a broad socio-economic impact. A port's reputation for reliability is key to its success, so ports that are more resilient to disruption from climate events should fare better (IFC, 2011) [9]. Therefore, ports need to strengthen resilience and adapt their infrastructure and relevant operations to the changing climate (WPSR, 2020) [10].

Greece has the most extensive coastline throughout the EU. In addition, there is a well-developed port network within the country due to its morphology and the existence of many islands. Therefore, Greek ports, as clusters of transport, energy, industry and "Blue Economy" [11], add significant value and contribute materially to the economy and society. Under the right conditions, they can be powerful accelerators for the circular economy and key strategic partners in achieving sustainable development goals (SDGs) and the objectives of the European Green Deal.

In particular, the adaptation of climate technologies in ports will enhance their "license to operate" and increase their economic and environmental competitiveness, which is expected to be critical to the "Blue Economy" of Greece [12]. Therefore, ports that want to achieve sustainable development must assess their ability to adopt such technologies and identify their strengths and weaknesses.

Ports' adoption of climate technologies will require financing from banks or investment companies. However, global investors rely on their ability to manage and avoid risk, and increasingly that risk is being framed in terms of investment exposure to environmental, social and governance (ESG) issues. Therefore, they are increasingly asking companies to evidence how they will comply with ESG requirements, particularly with regard to climate change. In addition to investor pressure, regulators around the world are increasingly pushing for climate disclosures.

Especially in the maritime industry that is entering an era where technological transition, climate change and shifts in government policy change their operating models, climate change adaptation is no longer a choice but an obligation. The European Sea Ports Organisation (ESPO) [13] proposes that EU legislation makes climate change adaptation a core principle in legislation and funding.

Recognising the needs for approaches to climate risk assessment and adaptation specific to ports that international institutions have underlined, the ESG-based methodology that was developed from the fund could provide a tool to port authorities to better understand their level of readiness to adopt climate technologies, help them identify gaps and needs for climate-related investments and enhance transparency towards their stakeholders.

3. The HRADF ESG-Based Methodology for Better Resource Allocation in Ports

Climate change has and will continue to shape the preference of investors and institutions shaping the market where HRADF operates. An example of this is the European Green deal, devised as a set of policy initiatives to make Europe climate neutral by 2050. This set of policies shape the investment priorities for the upcoming years and are designed to enable European communities to have access to funding mechanisms that support their climate transition strategies. The sustainability team at HRADF sought to support the mission of HRADF by proactively understanding whether the 10 ports under its management were prepared to adopt climate technologies from an organisational perspective. The sustainability team selected Climate Technologies as a theme as it is pertinent to climate adaptation and mitigation strategies, which are key components to be considered within the funding mechanisms of the European Green Deal.

3.1. Methodology Description

To assess the organisational readiness of the ports under HRADF management, the sustainability team had to address two challenges. First, identify an assessment mechanism, and second, define the KPIs to assess the readiness of ports.

Identifying an assessment mechanism was paramount as ports operate at capacity and currently do not have the incentives to take on additional tasks. Previously, HRADF had already communicated to ports about its plans to perform an internal initial ESG performance assessment. It would do so through the deployment of the HRADF ESG digital tool. With port management authorities having planned to complete the ESG assessment, the sustainability team saw this as an opportunity to gather information to understand the organisational readiness of ports to adopt climate technologies.

Defining KPIs required a three-stage process: first, identify dimensions relevant to organisational climate technology adoption; second, review the underlying ESG questionnaire and select relevant questions; third, define key complementing questions currently not included in the ESG questionnaire (Figure 1).

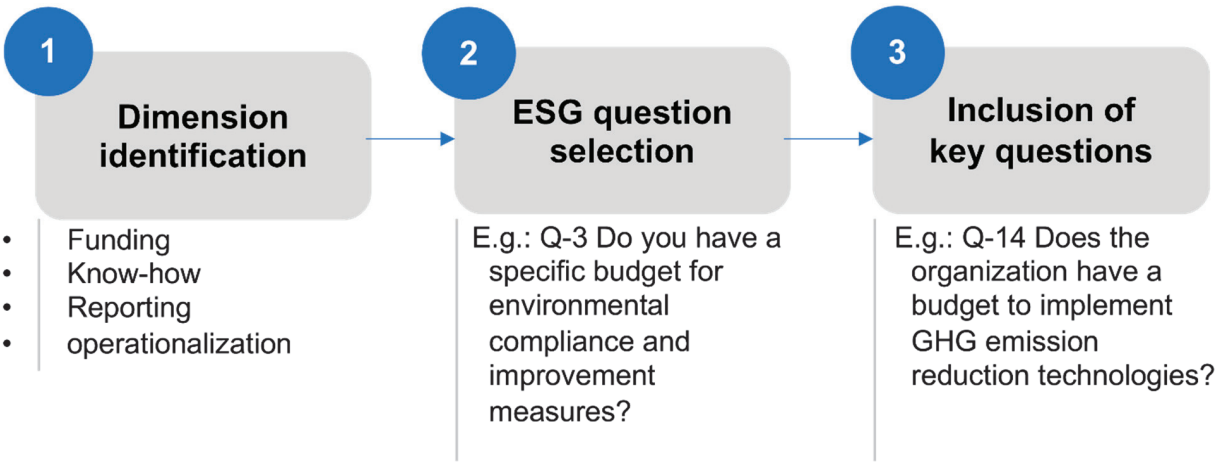

Figure 1. Three-stage process for defining KPIs.

The sustainability team conceptualised the KPIs' visualisation and its dimensions as a tool to provide executive decision makers with intuitive visual insights. In the context of this paper and HRADF's portfolio, the tool provides an overview of the state of ports to adopt climate technologies. The tool is built after the following framework [14]. The four dimensions are represented on an *XY* axis, and the performance of each axis is relative to its own dimension. The purpose is to create a visual standard that can serve as a comparative baseline between port's performance based on the thematic analysis (Figure 2).

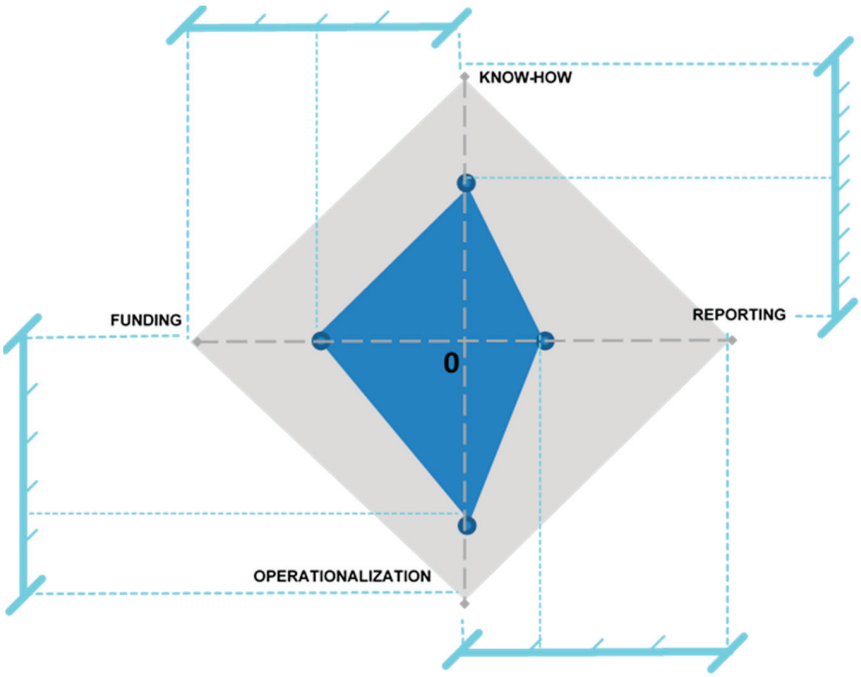

Figure 2. Visual standard for port's performance comparison.

The funding dimension focused on determining whether a port had access to funding. It considered two questions, the first already part of the digital HRADF ESG Rating tool and the second being an addition to the ESG Rating tool questionnaire:

1. Do you have a specific budget for environmental compliance and improvement measures?
2. Does the organisation have a budget to implement GHG emission reduction technologies?

The know-how dimension assessed research efforts and practicality of the actions in the short and long terms. Only the first question from the following was part of the digital ESG Rating tool:

1. On a scale of 0 to 10, to what extent are you investigating innovation and technology opportunities to minimise GHG emissions?
2. Rate from 0 to 10 your research efforts to adopt technologies to reduce your GHG emissions in the short term (1–3 years);
3. Rate from 0 to 10 your research efforts to adopt technologies to reduce your GHG emissions in the mid-term (3–5 years);
4. Rate from 0 to 10 your research efforts to adopt technologies to reduce your GHG emissions in the long term (more than 5 years).

The reporting dimension was concerned with organisational reporting initiatives, and the extent to which the port authority had set a corporate structure for their reporting efforts. No questions were added to this dimension. It includes the following:

1. Do you have committees responsible for decision-making on ESG topics?
2. Have you appointed an executive-level position or positions with responsibility for ESG topics?
3. Do you have staff or an officer for the day-to-day management of ESG topics?
4. Do you (or your parent organisation) endorse and/or implement reporting or international standards?

The operationalisation dimension explored decarbonisation efforts and the involvement of finance departments. No questions were added. This dimension includes the following KPIs:

1. Do you have a decarbonisation programme in place?

2. Do you measure GHG emissions (scope 1) and set reduction targets?
3. Do you measure GHG emissions (scope 2) and set reduction targets?
4. Do you measure GHG emissions (scope 3) and set reduction targets?
5. Does the organisation have an appointed person/team/function to incorporate GHG reduction technologies with current operations?
6. Does the finance department provide input in evaluating GHG reduction initiatives?

3.2. Presentation of the KPIs

Once the mechanism and the KPIs to assess the readiness to adopt climate technologies were identified, the digital ESG Rating tool was deployed throughout the ten ports under HRADF's management. In Figure 3, we present a simulation of the results for six ports. The simulation does not reflect the actual ports' performance. It is presented here as a practical visual aid. The grey area represents an ideal port scoring the maximum score possible in all dimensions. At the same time, it is visually intuitive to identify Port 3 as best in class among the group of the ports assessed, but that still needs improvement in the operationalisation, reporting and funding dimensions. On the other hand, port 5 and port 6 emphasise 2 of the dimensions, which signals that the other two dimensions need improvement.

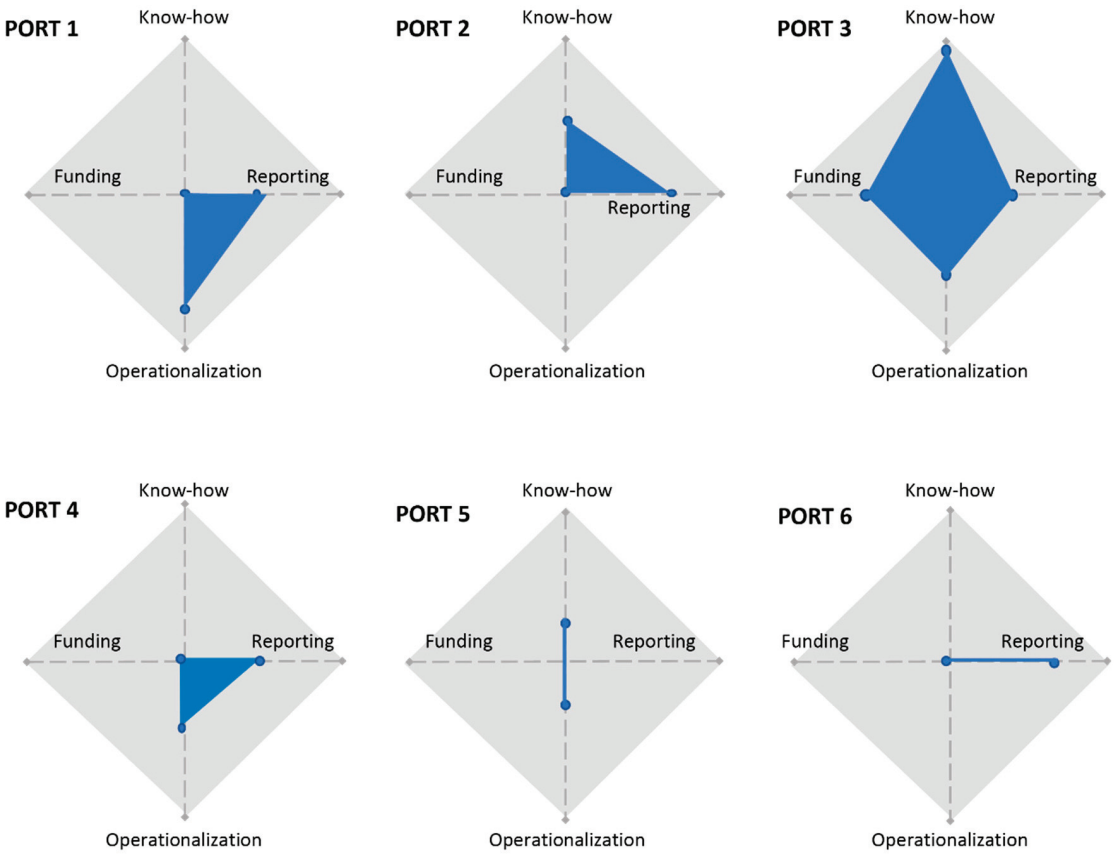

Figure 3. Simulation of the results of six ports of the HRADF's portfolio.

Within the asset development and resource allocation frameworks, the thematic methodology and visual analysis previously described present a practical decision-making tool. This approach can help executive leaders at an organization with multiple assets identify the assets needing improvement at a granular level. For example, when comparing the performance of the operationalisation dimension of port 1 to port 6, the lack of involvement of the finance department in sustainability activities combined with the lack of GHG emissions measurements are likely to be the reason for the underperformance

of port 6 on the operationalisation dimension. Depending on the organisational strategy, this insight could lead to developing an intervention targeting the organisational structure and operational activities of port 6 (change management). Additionally, this type of intervention can help optimise and prioritize the allocation of resources. For example, ports 5 and 6 are underperforming in different dimensions. While port 5 scores with the know-how and operationalisation dimensions and port 6 scores high with reporting, it is sensible to look at port 5 as a target for allocation of resources if the directive is to accelerate the adoption of climate technologies given that they already possess the know-how and have resources behind the operationalisation dimension. On the other hand, while port 6 might benefit from additional resources, the thematic and visual analysis provides a path to allocating these. For example, before allocating resources to the operationalisation dimension, improving the know-how dimension might make more sense.

4. Discussion and Concluding Remarks

This paper describes a methodology to assess the readiness of organisations to adopt climate technologies within the context of their transfer to private ownership from the perspective of a country asset development fund. It is worth mentioning that the work described in this paper is the first step and that further analysis is required to fine-tune the dimensions and the KPIs considered. Climate technologies (also known as cleantech, green technologies) as a thematic analysis was selected due to the potential benefits for the Greek blue economy. Future thematic analysis should target the assessment of critical resources efficiency and other topics such as governance transparency and inclusiveness.

While the team that developed the methodology and deployed it throughout all ports has experience with sustainability strategy and climate technologies, further development of the methodology requires the inclusion, or at least the input, of domain experts with an emphasis on organisational strategy.

The methodology described in this paper can serve as a starting point to initiate dialogue with ports' stakeholders. Moreover, it can be incredibly insightful for stakeholders interested in positioning Greece as a global leader at the intersection of climate technologies and maritime affairs.

Climate change directly impacts port operations and infrastructure. Given the critical role of ports in the global trading system and their potential exposure to climate-related damage, disruptions, and delays, enhancing their climate resilience is a matter of strategic socio-economic importance for the global economy and society (UNCTAD, 2020) [15].

Additionally, the recent pandemic has highlighted the need for ports to be prepared for drastic changes in demand and supply. The needed agility implies the modernisation of infrastructure systems. This modernisation is and will continue to be enabled by global economic packages, the European green deal, and the renewed visibility of ports as a critical element of global supply chains. This context provides the opportunity to utilise methodologies such as the one we propose as mechanisms to enable ports to allocate resources more efficiently to become more resilient and to take an active role in global decarbonisation efforts aligned with IPCC climate targets.

The crucial role of ports for a country's economic growth and development, the need for action on climate change adaptation, and resilience-building for ports are increasingly being recognised, including as part of the Global Climate Action Pathways for Transport and Resilience [16]; however, much more remains to be done. Until now, there has been very little analysis on how ports are affected by climate change, and even less evidence of how ready they are to adopt climate technologies. Therefore, the methodology presented in this paper provides a resource to understand the needs of ports leveraging the broad embracement of ESG assessment.

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Proceeding Paper

Teaching the Global Goals: Exploring the Experiences of Teacher Educators in an Online-Environment through Vignette Research †

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Abstract: The Teach4Reach research project explores how teacher education programmes can be leveraged to support the Sustainable Development Goals by raising awareness about the SDGs in teachers and teacher educators, and crafting future-focused research agendas on quality education, gender equality, reducing inequality and good health and wellbeing. It seeks to build international collaborative networks in teacher education to support the SDGs, and to support scientific knowledge development on the SDGs in education. As a data-generative strategy, the project utilises a series of online webinars that are coupled with research colloquia and vignette research. This paper shares the experiences of teacher educators from the inaugural Teach4Reach webinar through a vignette research methodology. In doing so, the paper echoes the challenges and opportunities presented in online environments. How do teacher educators experience online environments themselves in the search for quality education? Based on the vignette findings, the paper advocates for a revisitation of the four pillars of education: Learning to know ("the educator understands"), learning to do ("the educator is able to…"), learning to live together ("the educator works with others in ways that…") and learning to be ("the educator is someone who…").

Keywords: teacher education; teacher educators; sustainability; SDG 4; vignette research

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1. Introduction

Teacher Educators are powerful agents of change with the ability to support the educational mission needed in the context of sustainable development. Their knowledge and competences are crucial for sustainable teaching and learning and can shape values and perspectives, and develop skills and concepts for pre-service or in-service teachers. This study posits that universities and schools should be experiential places of learning for sustainable development as a role model, and should therefore orient all their processes towards principles of sustainability [1,2] (p. 47).

The Teach4Reach project views teacher education as a critical pivot to attaining the Sustainable Development Goals in Agenda 2030. Some studies [3] (pp. xvii) indicate that only 7% of Teacher education programmes cover education for sustainable development and that it remains disconnected within the curriculum [4] (p. 7). Teachers can play an important role in creating awareness about sustainability. It is also widely accepted that effective teachers are the most important factor in a students' learning. With less than ten years left until 2030, the percentage on sustainability sciences in teacher education curricula

needs to be increased substantially, in order to create global awareness of the criticality of the global goals for intergenerational equity, and for economic, environmental and social sustainability. Current crises like the Corona pandemic, also point towards the necessity of the implementation of new skills for creating global awareness in Teacher Education of sustainable development and the SDGs.

Though all 17 Global Goals are relevant within the field of education, the Teach4Reach project prioritises four SDGs, e.g., Quality education, Gender equality, Reduced inequalities, and Good Health and Wellbeing. The rationale for the focus on these four SDGs is its people-focus and the urgency of these SDGs in both the South African and Austrian contexts from where the study originated. Basic education can be critical to educating youth about the societal challenges such as gender-based violence, poverty reduction through reduced inequalities and the long-term effects of investments in quality education and wellbeing. In the advent of the fourth industrial revolution where technology plays a prominent role, there is substantial potential in the affordances of technology and teacher education to make progress on sustainable development in the areas of quality education, gender equality, reduced inequality, good health and wellbeing. By infusing the SDGs in teacher education and teacher professional development curricula, early sensitisation in pre- and in-service teachers can potentiate teachers to come up with practical solutions for sustainability in the classroom. Problem based learning is one way in which knowledge can be imparted. It can also help develop critical problem solving skills and values through teaching. This will be one of many avenues explored during the course of this project.

One essential factor for implementation of the SDGS is to enable a more sustainable and just society for all qualified teachers. For this, teacher education has to respond to transformation processes [5] (p. 29) and has to encourage changes in knowledge, skills, values and attitudes [2] (p. 9). Teacher Education must therefore meet these challenges and deliver a reorientation towards an Education for Sustainable Development [6]. How do teacher educators support Agenda2030 and specifically Sustainable Development Goal 4 on Quality Education even as they negotiate the changing landscapes in education?

2. Methods

The Teach4Reach research project adopts a mixed-methods methodology, which is founded in phenomenology. It employs a combination of vignette research, in-depth interviews and artefact gathering to collect data. This paper reports on the vignette research section during the initial phases of the study.

The complexities of the synergies between teacher education and the Sustainable Development Goals (SDGs) necessitates a qualitatively nuanced research methodology, in this instance–vignette research. Infusing teacher education curricula with knowledge and awareness of the SDGs is a multi-layered process that requires finesse and in-depth understanding of the dynamics at play and a vignette methodology can serve this purpose.

The Teach4Reach research project leverages a two-year webinar series on teacher education and the SDGs (Global Goals teaching) to build a key group of researchers in teacher education who prioritise the sustainable development goals in teaching and research. The six webinars over the two-year period provide safe spaces for the sharing of ideas on ways in which teacher education curricula can be reformed or shaped to contribute towards the achievement of the identified sustainable development goals. International experts in sustainability sciences also contributes to the discussions.

Within this framework of the webinar series, the status quo of the SDGs and teacher education are researched in teacher education programmes from the Global South and the Global North. The audience of the webinars and the sample for the data collection for the project are Teacher Educators in Austria and South Africa and pre-and in-service students (undergraduate and postgraduate) from a variety of scientific disciplines. The two groups are important stakeholders for the implementation of the SDGs in Teacher Education. The connection between different stakeholders (groups and from different

countries) also provides a platform to share ideas, and to rethink critical current concepts in teacher education and sustainability.

Concurrent to the webinar series, the project focuses on the development of the next generation of teacher education researchers who focus on sustainable development. As such, the webinars and the research project may also potentially provide innovative and sustainable ideas that provide a holistic and transdisciplinary character for lifelong learning. The study actively seeks future developments that can be initiated to consider the four selected SDGs in teacher education programs.

2.1. Rationale for the Teach4Reach Project

Expanding the critical mass of researchers and future teachers, who contribute to knowledge development in the sustainable development goals within the realm of global teacher education, can serve as a key strategy to attaining the global goals as presented in Agenda 2030.

The primary research question in the Teach4Reach project is:

How can teacher education programmes be leveraged to support Agenda 2030 and the sustainable development goals?

The secondary research questions in the Teach4Reach project are:

(a) In which ways do the SDGs currently feature in teacher education programmes from the Global South and the Global North?
(b) How can quality education, gender equity, inequality, and good health and wellbeing be improved via teacher education programmes?
(c) What can a university didactic setting that realizes the above-mentioned SDGs-goals, within the framework of teacher education programmes look like in concrete terms?

2.2. Research Question

For the purpose of this paper, the research team zoomed in on the experiences of teacher educators during high-level discussions on the role of teacher education programmes to support Agenda2030. The research question in this paper therefore is:

How do teacher educators experience online discussions on quality education?

The rationale for this level of analysis, is the assumption that teacher educators play a pivotal role in the ways in which future teachers will engage with the science of sustainability broadly, and quality education (SDG 4) specifically. Deeper understandings of their personal lived experiences may therefore potentially contribute to more engaged learning environments in the future.

2.3. Research Setting and Participants

An integrated process that couples research team meetings, before, during, and after each webinar, is followed in the broad research project. Within this process, the vignette research methodology is regarded as a highly suitable methodology to capture tonal variation as teacher educators and students engaged with SDG materials and discourses, even in virtual settings such as interactional webinars.

This paper reports on a section of the data collected at the inaugural Teach4Reach webinar which took place mid-year in 2021. The focus of the webinar was on SDG 4 (Quality education). The webinar was hosted from the Future Africa campus of the University of Pretoria. Registered participants (n = 109) included virtual delegates from Mauritius, Mozambique, Zimbabwe, Kenya, Sudan, Austria, Italy, France, Germany, Canada and the United Kingdom. An additional group of virtual participants (n = 136) engaged via livestreaming on youtube.

2.4. Vignette Research

As stated, the primary vignette methodology used in this project is associated with the "Innsbruck Vignette Research" approach, an innovative phenomenological approach to empirical school research, which attempts to capture and analyse the experiences of

students in school [7,8]. Hence, a special focus is placed on experiences regarding the quality of education, gender issues, (in-) equalities and individual well-being. The challenge for researchers is how to capture these experiences while in the field. Therefore, researchers in the field attempt to stay open and are particularly attentive to pathic elements such as atmosphere, facial and bodily expressions and tone of voice of pupils and teachers. These details are collected by researchers in protocols, which then form the basis for writing the vignettes. The vignettes are thick descriptions of the lived experience of the researchers and as close as possible to the experience of the participants in the field. Due to the linguistic expansion, vignettes are best understood as a form of literary non-fiction in which researchers strive to manifest and point to the impossible plurality of the experience by revealing the pathic qualities of a tangible moment perceived by them. To ensure that the researchers communicate the essence of the experience of the participants as completely as possible without adding their own interpretation, the individual genesis of a vignette is documented, then communicatively validated with the participants in the field and through a workshop method within a research team.

Once vignettes have been crafted, they become the primary data for phenomenological analysis, a process referred to as "vignette reading". In reading a vignette, researchers engage in the experience as readers, holding back from categorizing and explaining in order to uncover, peel off and add layers of understanding to what is given. Hence, an appropriate interpretation of data in the phenomenological tradition is one which "points to" phenomena of experience rather than "points out" findings [9].

From a university didactic perspective, vignettes are also used as instruments of professionalization by making experiences regarding the quality of education, gender issues, (in-) equalities and individual well-being comprehensible. Hence, they can contribute to a sustainable change in the attitude of (future) teachers and teacher educators, as in this case the sustainability agenda.

In the project, vignettes are used as research instruments during the webinars, to capture the experiences of the participants in the webinar and guarantee a learner-oriented perspective on the four selected SDGs. In this paper, the vignettes focus on SDG 4 on 'Quality education'.

2.5. Data Collection and Ethics

Ethical clearance was provided by the Ethics Committee of the Faculty of Education at the University of Pretoria (UP) (EDU049/21). Additional approval for the study was granted by The UP Survey Coordinating Committee on 4 June 2021.

Data was collected during the second breakout session of the webinar. Participants were informed of the study at multiple timepoints, e.g., webinar invitations, on the webinar programme itself and during the proceedings. Participants consented to the sessions being recorded.

The broad theme of the second breakout session was stated as, 'Understandings of sustainability and quality education in the global context'. Within each breakout group, the open discussions were guided by the following questions/themes:

- How can teacher education programmes be leveraged in the future, to support Agenda 2030 and the sustainable development goals?
- Welchen Beitrag können LehrerInnenbildungsprogramme zukünftig leisten, um die Agenda 2030 sowie die Ziele für nachhaltige Entwicklung zu unterstützen? (German parallel session).
- In which ways do the SDGs currently feature in teacher education programmes from the Global South and the Global North?
- How can quality education (SDG4) be supported and improved via teacher education programmes?
- Within the framework of teacher education programmes, what can a university didactic setting that realizes the SDGs-goals, look like in concrete terms?

A vignette researcher was allocated to each breakout room. The vignette researchers captured observation data as the dialogue under each of the questions/themes unfolded. In this paper the vignettes that emanated from three of the sessions are shared, e.g., the sessions that addressed the questions, "How can teacher education programmes be leveraged in the future, to support Agenda 2030 and the sustainable development goals?", its German parallel, "Welchen Beitrag können LehrerInnenbildungsprogramme zukünftig leisten, um die Agenda 2030 sowie die Ziele für nachhaltige Entwick-lung zu unterstützen?", and "Within the framework of teacher education programmes, what can a university didactic setting that realizes the SDGs-goals, look like in concrete terms?".

2.6. Data Analysis

Vignette research precipitates the process of data analysis in that it entails an iterative-generative process. Raw vignettes are crafted from synchronous observation data and then developed in subsequent processes of refinement until final vignettes are presented. For the purpose of this paper, three vignette researchers crafted raw vignettes, presented it to critical readers, and then refined the vignettes. Iteratively, the final vignettes then also present a new level of data sources. Three vignettes are presented here.

3. Findings

As stated, the findings from the study are presented via three vignettes. As such, it depicts the critical minutiae at play during complicated discussions on matters of quality education, teacher education and sustainability.

3.1. Vignette 1

The scene takes place during a breakout session in a webinar on the topic 'Supporting the Agenda 2030 in Teacher Education'. After a presentation the participants are invited to join one of five breakout sessions. This breakout session focusses on the topic 'How can teacher educations programmes be leveraged tin the future to support Agenda 2030 and the SDG's?' and there are just over 10 participants from Europe and Africa in the session. After an introduction by the moderator, Wilma, a first participant shares his thoughts on the topic. Once he finishes Wilma thanks him for his input and asks the participants if there are any remarks, questions or ideas that they would like to share. Derek raises his hand digitally and Wilma acknowledges this by saying his name and that he wants to say something. Derek turns on his camera and unmutes his microphone. He beams into the camera with eyes wide open and a smile from cheek to cheek. He lifts his head slightly while inhaling audibly and opens his mouth in one gesture. At this moment Wilma begins speaking again. Derek lowers his shoulders and tilts his head downward. His gaze descends and fixates on his desk directly in front of him. He furrows his eyebrows and the corners of his mouth turn slightly downwards. He mutes his microphone. Wilma finishes what she wanted to add and calls Derek by name again and asks him to pose his point. Derek's facial expression changes instantly. He raises his shoulders, tilts his head back and lifts the corners of his mouth to a broad smile. He raises his eyebrows and his eyes are wide open. The tone of his facial muscles is relaxed. Derek proceeds to talk and introduces himself in a hasty manner. He points out that unlike the other participants, he isn't an expert on the subject, but that he would like to raise a question. His facial expression and tonality change. His eyebrows are furrowed and the smile is replaced by a neutral expression of his lips. His eyes aren't wide open anymore and his gaze seems focussed and fixated on the bottom of his screen. He tenses his face muscles. His speech is slow and clear. He asks about possible collaborations and how they can be achieved, as he sees them as necessary in order to reach all students. After his question, his tonality and facial expression return to relaxed smile that he showed when he initially started talking. His eyes are wide open again and his eyebrows are slightly raised. He says that he would like to hear other opinions on this matter, thanks Wilma and turns off his webcam and mutes his microphone. Wilma thanks him and asks participants to share their thoughts on the matter. Meryl, another participant,

raises her hand digitally. Wilma acknowledges her and asks her what she would like to say. Meryl unmutes herself, turns on her webcam and starts to talk. She speaks for roughly 5 min on an unrelated matter that doesn't connect to Derek's question. Derek's screen remains dark and his microphone remains muted for the rest of the breakout session.

3.2. Vignette 2

"I warmly welcome you to topic 2", trumpets Angelika, the facilitator of the German-language breakout session into the "Zoom" round. She frowns, squints her eyes, before her face relaxes into a broad smile. Her eyes wander searchingly over the screen before Angelika briefly introduces herself. She welcomes the experts from Austria invited for this session, the two students Lisa and Verena, the teacher educator Sarah, and Lucas, professor and Unesco Chair for Global Citizenship Education. Then, with a short welcome, she turns to the remaining five people present in this session. "I would have thought that the experts would open a small round of reflection", Angelika suggests. She shares her screen and shows the audience a promotional video summarising the goals of the 2030 Agenda, especially SDG4. She then gives the floor to the invited experts with "I would be interested to hear what the four experts have to say". Almost immediately Lisa, one of the two students, then the student Verena, then the teacher trainer Sarah speak up. In addition, a South African professor intervenes with a request to speak. The discussion revolves around lone wolfism in teacher education, inequalities and the lack of implementation of SDGs even in privileged teacher education programmes. Suddenly the discussion stops. Lucas clears his throat: "I'm actually quite happy that I was able to listen to you first", he says thoughtfully, before adding. "What are the experiences?" He pauses, then continues, "It's about habitus reflexive action, or actions in need to be questioned". He says with determination: "It's not just about what doesn't work, but the question is where can we discern and start?".

3.3. Vignette 3

Silence dominates the unknown situation. Time ticks on as everyone introduces themselves and the contexts in which they function. As the kaleidoscope of participants keep quiet to await the instructions, no virtual eye-to-eye contact is made. Tobias, the facilitator, eagerly opens up the discussion on Sustainable Development Goals to everyone. Olivia excitedly makes it known that she knows Mia, as they attended the same rustic school in Swaziland. Smiles are seen on the split screens. "Consciousness is a crucial point for Sustainable Development Goals", comments Olivia. "Teachers should be taught how to incorporate Sustainable Development Goals into education", proclaims Mia. "We all know how important experience is", responds Tobias. Everyone looks away; there is once again a resounding silence and awkward online presence. The operating light is still blinking, but it is returned with blank expressions. The distant humming sound of a ringing cell phone jolts the group back to reality. In an attempt to pick up where the quiet ended, Charlotte charges into a sentence: "It is not about knowing, but about being". The conversation ensues. "I agree", says Tobias, "a total human experience is crucial". Suddenly, another screen opens and a seventh participant makes an appearance—Petra from Berlin. In a soft, almost shy voice, Petra lowers her head and whispers into her mic: "Empathy and social emotional competencies should be taken into account in education". Paying close attention to what Petra has to say, Monika, in a more boisterous tone, elaborates on the importance of inquiry-based education, insisting that "it is one of the key aims in the future". Amara's screen is muted. She does not venture into the discussion, for now. "But what should teacher education look like in the year 2030?" inquires Tobias, seeking to steer the conversation in a particular direction. "I would like to see more assessments in the future and not standardised tests", remarks Mia. "That's profound", chirps Tobias excitedly as he puts the tip of his pen in his mouth, "I think you are touching on an important aspect". "Well, in my view the curriculum should be value-driven", utters Amara next. "Education by nature is value-driven", affirms Emily with a knowing smile. Not quite sure of what to

say next, "I wish to see teachers as lifelong learners", adds Olivia. "These are all valuable remarks", exclaims Tobias, as it appears everyone is still listening to the rhythm of the questions and answers. "Every voice must become one", retorts Monika. "Marvellous", replies Tobias as he glances at his watch and responds: "We'll have to leave it at that until next time". As each person disconnects, the images on the screen go blank like a thick heavy curtain closing out an audience and a deafening silence falls.

4. Discussion

The three vignettes portray three distinct experiences during the same timeframe, within the same webinar on SDG 4 (Quality education), within three separate breakout groups. Simultaneously, it illustrates the uniqueness of personal participatory experiences, even as it describes the complexities of high-level discussions on the interactions between teacher education, quality education and the broad sustainability agenda.

It has been established that higher education institutions are key for the implementation of sustainability principles and also that sustainability based curricula and culture change is key to mindset transformation to support Agenda2030 [10]. This role of higher education institutions necessitates the need for increasing interdisciplinarity. As such, calls for a more systematic introduction of the SDGs in university programs have also gained momentum [11], and are finding support in projects like the Teach4Reach project.

In Vignette 1, the interactions between a group facilitator and a highly experienced group of educational and interdisciplinary researchers are portrayed. In this vignette, technology brings anonymity behind muted screens, even as it decreases the geographical distances between participants. The timeframe within which the discussion must take place, creates urgency, and the impetus of individual contributions reduces the opportunities for in-depth connections in between individual contributions. Non-verbal communication is tangibly experienced and amplified by projections on a flat screen. Even though the intellectual contributions to the discussion seem to be rich and intricate, the potentiation of new network-development and post-webinar follow-up are absent.

In Vignette 2, which captures some of the dynamics of the German parallel session on the same question (hence the German punctuation), the intricate dynamics between the group facilitator and the wider group of participants are again central in the storyline of the vignette. The conversational rhythms, mediated by technological interaction, are presented as staccato at some points, abrupt in others, and sometimes even on a vanishing continuum. The participants are concurrently listeners and contributors. Privilege and inequality, individualism, and intimacy of connections within a global world are implicitly present in this vignette. The vignette ends with a strong appeal to also find (hinspűren) what is working in education.

Vignette 3 presents a corporal (e.g., bodily) experience of an online breakout session and it also expands the sensory 'picture' of the session. The affective effect of two participants connecting online after many years, ripples through the session and creates a moment of poignancy in a discussion on global education. The global becomes local. The unknown becomes familiar. Yet, the silences and the abruptness of screens opening and closing also generate the same ambiguities within a 'learning' environment, that are present in the previous vignettes.

There are scenes of similarity that present in all three of the vignettes: the challenges of turn-taking during online discussions, the impunity of "raising" of virtual and actual hands, and the unintended silences that interject the attempts at meaningful discussions. In all instances, the critical role of the facilitator is wellknown in the education realm, yet pertinently re-emphasised here.

In a systematic review of the literature on Education and SDGs [12] the importance of the acquisition of commitment and participatory processes have been emphasized in order to ensure optimal support for the SDGs in education. These authors [10,12] have argued that Education for Sustainable Development (ESD) should become the essence of teaching and learning at tertiary institutions, and also that educational institutions are to

be guided in the process of incorporating the SDGs, allowing for contextual adaptability and acknowledgment of the level of institutional commitment.

This paper illustrates the embedded advantage for studies that are investigating education in education. The lived experiences of participants during an online webinar on Quality Education (SDG 4) in this study echoes the lived experiences of teachers and students around the globe. Education researchers are learning along with all students. The personal becomes public and the learnings become pervasively applicable. If we, as educational researchers, struggle within the new realities of technological platforms, newfangled power dynamics and the vastness of possibilities, what are the implications for the students and teachers of the world? How do we support Agenda2030 and specifically Sustainable Development Goal 4 on Quality Education?

The relationship between teachers and society, their values, attitudes and behaviours with regard to sustainability have been broadly connected to the four pillars of education [13]: Learning to know ("the educator understands"), learning to do ("the educator is able to…"), learning to live together ("the educator works with others in ways that…") [14] and learning to be ("the educator is someone who…") [15,16]. The initial findings (and vignettes) in this paper, presents an appeal for a revisit to the four pillars of education in new ways that capture the new realities of education.

5. Conclusions

Teacher education programmes present a critical vehicle whereby Agenda2030 broadly, and SDG 4 specifically, can be supported. This paper presents the lived experiences of teacher educators as they grapple with the tenets of quality education in an online environment. As stated, the Teach4Reach project seeks to explore the ways in which teacher education programmes can be optimized to support sustainability. The paper presents an argument that education researchers are in a unique position to excavate their own learning experiences, in order to arrive at deeper understandings of learning processes; and thus potentially be able to contribute to a revisit of the notion of the four pillars of education [12], i.e., Learning to know, Learning to do, Learning to live together and Learning to be.

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Proceeding Paper

The Global Green New Deal: The New Norm? †

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Abstract: The Global Green New Deal (GGND) has had a resurgence through calls for 'building back better' from COVID-19 by way of a green recovery. News headlines suggest that the world has, so far, missed this opportunity, yet close analysis of the data reveals a more subtle trend at play. An aggregate analysis of COVID-19 stimulus measures from the perspective of plurilateral summit institutions reveals that both the G7 and the BRICS countries have implemented a proportionally higher volume of clean versus dirty stimulus measures. This indicates that the GGND could indeed be 'the new norm' even as it continues its nascent emergence. However, a significant gap remains between the G7 and the BRICS countries in their respective proportions of clean versus dirty stimulus measures. Given the role of the same groupings as respective net carbon importers and net carbon exporters, there remains an ongoing risk of 'carbon leakage'. In making this connection, this paper underscores the potentially crucial role that carbon border adjustment measures will play as the GGND continues to emerge as a possible 'new norm' of global governance.

Keywords: Global Green New Deal; global governance; COVID-19; green recovery; international trade

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1. Introduction

Through strategic public investments in sectors such as energy, transport, and industry, a Global Green New Deal (GGND) seeks to decouple economic development from carbon emissions, when rebuilding an economy post an economic shock. The GGND was first proposed in 2009 by the United Nations Environment Program (UNEP) [1]. The UNEP's proposal for a GGND included three elements, domestic stimulus, public policy change, and international coordination [1]. Plurilateral summit institutions (PSIs) play major roles in driving the latter and, as such, form a major part of the contemporary global governance landscape. Given that they also represent a sizeable share of the global economy and greenhouse emissions, PSIs also play key roles in either driving forward or hampering progress towards a GGND [2,3]. The resurgence of the GGND framework in 2019, when paired with the opportunity of 'building back better' from COVID-19, presented the first window to assess the practice and consequences of the GGND for global governance from the perspective of PSIs.

This paper takes an early opportunity to explore empirical variation in the green recovery practices of the G7 and BRICS countries in their recovery from COVID-19 through a novel interrogation of open-source data from the Global Recovery Observatory database. Then, it considers how this practice may impact global governance, specifically from the perspective of the trade–climate nexus. The paper begins by outlining the original GGND framework and its normative resurgence in 2019. Section 2 continues with an overview of the link between the GGND and 'building back better' and provides early insights as to the implications of this practice of the GGND for the trade–climate nexus. Section 3 describes the methodology of the paper, including the datasets it analyses and the framework of the 'norm lifecycle' it employs. Section 4 discusses the findings of the results, and their implications for global governance. Section 5 presents a summary of the ways in which the GGND can and cannot yet be considered the 'new norm'. Given the preliminary nature of

this research and considering the ongoing nature of the COVID-19 recovery, this paper also outlines areas for future research throughout.

2. Research Background

The GGND can be conceived as a norm bundle containing norms that facilitate the twin goals of decarbonisation and development. To understand the foundation of the GGND as a norm bundle, one must examine the constituent elements of the original framework. Since the GGND framework has evolved since its conception, it is also necessary to assess its form and substance in light of its recent resurgence and, only then, is it possible to view the opportunity that COVID-19 provide through calls for 'building back better' from COVID-19. While the GGND is a nascent trend, it is already prompting divisions among the PSIs, including the G7 and the BRICS countries. In turn, contention over green recoveries in global governance are being expressed in the domain of international trade. In this way, the trade–climate nexus is key to the normative diffusion of the GGND. The following section provides an introductory commentary in each of these areas.

2.1. Understanding the Global Green New Deal

The UNEP outlines three broad objectives of the GGND: to make a major contribution to reviving the world economy, to reduce carbon dependency and ecosystem degradation, and to further sustainable and inclusive growth [1] (pp. 5–6). To reach these objectives, the UNEP describes three core elements of the GGND. The first is state-led economic stimulus [1] (pp. 6–9). This stimulus should decarbonise carbon-intensive sectors such as energy, transport, buildings, and agriculture [1] (pp. 6–9). The second element is domestic policy reform [1] (pp. 9–12). Reforms include eliminating environmentally harmful subsidies and strengthening environmental legislation [1] (pp. 9–12). Complementary to domestic stimulus and policy reform, is the third element, which is international coordination [1] (pp. 12–16). This element includes changes to the policy architecture governing international trade, aid, global carbon markets, and technology transfers [1] (pp. 12–16). The GGND was launched in response to the global financial crisis. Upon release, it received a degree of domestic support from states, including being part of former U.S. President Barack Obama's legislative agenda [4]. Yet, its uptake remained limited and consequently, the world saw an increase in greenhouse gas emissions that soon exceeded levels seen prior to the global financial crisis [5] (pp. 3–8).

2.2. The Normative Resurgence of the GGND

Recent legislative and policy proposals reveal a resurgence of the GGND. In 2018, as part of the IPCC report on reaching the 1.5 °C temperature target of the Paris Agreement, a policy of achieving 'net-zero' emissions was recommended [6]. The next question was "How could this be achieved?" The answer was provided by Congresswoman Alexandra Ocasio-Cortez as part of a rallying call for a proposal for a Green New Deal [7]. Following this, a Green New Deal Bill was tabled in the United States [8]. Although the bill failed to pass, it sparked a wildfire of debate with embers travelling across oceans, with proposals that were also tabled in the United Kingdom, European Union, and Australia [9–11]. Local green new deals were passed by a range of local and state actors, including London and New York [12,13]. These proposals for broader green new deals have seen more varying degrees of success, yet all have provided insight into the normative character of the GGND. It is from this foundation that the GGND's normative resurgence in response to COVID-19 prompted calls for 'building back better'.

2.3. Building Back Better from COVID-19

Proposals for a GGND have been further amplified by calls for 'building back better' from COVID-19 [14]. 'Building back better' is a term that pre-exists COVID-19 and implies an opportunity for resilient, inclusive, and environmentally friendly recovery, post disasters [15]. To that end, the United Nations General Assembly urged states to implement a

"climate and environment responsive approach to COVID-19 recovery efforts" [16]. States have since recognised the importance of 'greening' their COVID-19-related domestic stimulus packages [17]. The European Union, the United Kingdom, and South Korea stand out as particular 'norm entrepreneurs' of the GGND through their policy plans to explicitly respond to COVID-19 by way of a green recovery [18–21]. Countering norm entrepreneurs are 'norm antipreneurs' who seek to disrupt norm diffusion of the GGND [22] (p. 311). Examples of states acting as norm antipreneurs of the GGND include Russia and Saudi Arabia [23,24] (pp. 10–11, 13–14). At the same time, international organisations are also increasingly embracing their roles in coordinating the 'global' element of the GGND [25–27]. Therefore, both state and international organisations can be viewed to form a 'community of practice' of the GGND [28]. PSIs, such as the G7 and the BRICS countries, are intermediaries among state and international organisations, possessing qualities of both. Thus, with this context in mind, PSIs are a useful perspective from which to assess the norm development of the GGND.

2.4. Plurilateral Summit Insitutions as Norm Entrepreneurs and Antipreneurs

The increasing uptake of green recovery has consequences for the long-term decarbonisation trajectories of states and collectively informs the chances of the world obtaining the temperature targets of the Paris Agreement [29]. Yet, for global governance, there is already a clear schism emerging among the PSIs. Norm entrepreneurs of the GGND, including the European Union and United Kingdom, have strongly influenced the activities of the G7 and G20 to act as a vehicle for norm diffusion. This has resulted in the G7 members committing to a green recovery in their Carbis Bay Communiqué [30] and the first recognition of the importance of carbon pricing by the G20 Finance Ministers in their Rome Communiqué [31] (p. 3). G7 member states have now all committed to green recoveries domestically, prompting unprecedented levels of climate-specific funding. Leading examples of this are the European Union's Next Generation EU project which directs one third of its spending to climate change and President Biden's proposed Build Back Better framework which directs a significant stimulus to clean energy as a backbone of America's ongoing economic recovery [19,32]. Members of the G7 built on this track record in their efforts at COP26 in November 2021. This included expanding the Build Back Better World (B3W) plan first launched at the G7′s Carbis Bay Summit and which sought to offer climate-conscious infrastructure investment [33]. Similarly, COP26 was also used as a platform for G7 members to announce collaborative plurilateral and bilateral partnerships with key BRICS countries, including South Africa and India [34,35]. These are illustrative of the kinds of nascent, yet innovative, approaches that norm entrepreneurs take to diffuse the GGND's norms.

By contrast, the norm antipreneurs amongst G20 member states have largely been attributed as reasons why G20 members, collectively, did not go further in agreeing to phase out coal in the G20 Leader's Communiqué. The BRICS countries are also in an interesting position, having signalled varying degrees of commitment to green recoveries, ranging from China's commitment to a net-zero target by 2060 through to Russia's active rejection of the notion of a green recovery. At COP26, BRICS countries India and China also intervened in the closing moments of COP26 in November 2021 to change language from 'phase out' to 'phase down' coal [36]. This clearly indicates that, while norms such as the GGND's energy transition norm are now seen as inevitable, there remains ongoing disagreement about the breadth, depth and timing of this transition. The divergence in the practices of PSIs reveals ongoing contestation over the normative diffusion of the GGND within global governance.

2.5. Implications of the GGND as the New Norm

The contestation of the normative character of the GGND is representative of the real-world implications it brings with it. The elements of the GGND are inherently interconnected and it is the trade–climate nexus that offers the best view of this connection. For

example, without trade protections in place, changes in the domestic policies of states due to the GGND may result in 'carbon leakage'. At the same time, mechanisms to prevent this through border adjustments could be challenged as a breach of World Trade Organisation (WTO) rules. Domestic green stimulus is also at risk of breaching the WTO's rules on subsidies. For these reasons, the GGND's international element could be simultaneously and mutually constructive in the form of climate clubs, or destructive in the form of a dispute resolution at the WTO. Other articles in the literature have examined the nuances inherent within the trade–climate nexus in much greater detail [37–39]. This paper, instead, seeks to review the risks it carries with the benefit of early empirical insights into the practice of the GGND.

3. Methodology

The world is still in the midst of efforts for 'building back better' from COVID-19. The current literature suggests that there is a large gap between this rhetoric and real-world practice [40–42]. However, most assessments either view the green recovery response as an aggregate or at a country-level basis. This neglects the role of PSIs which, as outlined above, play unique roles in norm building in global governance. To explore the roles they play, this analysis examines the green recovery practices of PSIs, as well as the implications of this for the trade–climate nexus. The presentation of two empirical snapshots of both domains doubt presents a crude picture. Therefore, it is important to highlight that this methodology only intends to provide a preliminary insight which should be continually tested as further practices develop.

To gauge the practices of the G7 members and the BRICS countries, first, this research analysed the open-source data from the Global Observatory Recovery database (GRD) [43]. The GRD was created in partnership between the University of Oxford, the UNEP, the Global Fiscal Policy Network, the German Agency for International Cooperation and the International Monetary Fund, PAGE, and the United Nations Development Program. As a database, the GRD provides the most comprehensive assessment and categorisation of the fiscal policies of a diverse range of countries [44] (p. 8). The GRD is an open-source database and is updated regularly as more recovery data become available. Updated versions of the GRD are released periodically to the public. This assessment employed the dataset versions released on 10 March 2021, 23 May 2021, and 11 October 2021, successively.

The objective of the GRD is to classify fiscal policy measures that form part of the economic rescue and recovery from COVID-19. For this task, the Global Recovery Observatory created an exhaustive system of 5 typologies, 40 archetypes, and 158 sub-archetypes [43]. Then, the Global Recovery Observatory used a sophisticated Likert assessment to determine the environmental, social, and economic policy impacts of the archetypes [44] (p. 6). Assessments of greenhouse gas emissions under the archetypes are uniquely subject to consideration of both the short-term and long-term emission profiles, given the differential impacts that both bring [44] (p. 6). In this way, archetypes are categorised to clearly distinguish between policies that support and harm the objective of combatting climate change [44] (p. 6). It is on this basis that the GRD categorises archetypes as either 'clean' or 'dirty' stimuli. 'Clean' stimuli include measures such as investments in renewable energy or clean transport. 'Dirty' stimuli include measures such as investments in oil and gas operations as well as airlines. This assessment focuses on the direct proportion between clean and dirty measures as being indications of the trends in the green recoveries amongst PSIs. However, for most measures, the database also provides data on the economic size of each measure (both in real terms and standardised to the U.S. dollar). Once this aspect of the database is finalised, the data could also be used for a more wide-ranging analysis of the volume of dirty versus clean spending and not only the proportion.

While the green recovery practice may initially be at a domestic level, the international trade effects are not far behind. The notion of 'net-zero' has increasingly become intertwined with the objective of the GGND and its intermediary by way of a green recovery. Examining the implications of this for PSIs also requires an examination of the latest trends in the

carbon intensity of international trade. The newly established Climate Dashboard of the International Monetary Fund provides open-source data for this purpose [45]. This analysis used these data to aggregate the net carbon intensity of trade for the G7 members and the BRICS countries from 2009–2019 and plots them for visual analysis.

To connect these snapshots of green recovery practices of PSIs and the carbon intensity of their international trade, this analysis adopted Finnemore and Skikkink's model of the 'norm lifecycle' [18]. The norm lifecycle begins with norm 'emergence', where norm entrepreneurs seek to persuade other network participants of the value of a norm [18] (p. 898). Then, norms reach the stage of 'cascade', where through socialisation, states and other actors see norm adoption as a means of enhancing their legitimacy [18] (p. 898). Once norms have cascaded, they become internalised within the system. It is at the stage of 'internationalisation' where conformity with norms is sought and is reflected in professional and bureaucratic settings such as law and policy [18] (p. 898). Applied to the case at hand, it was green recovery practices that provided the best proxy for the emergence and cascade of the GGND as a source of norms and the international trade system that offered the best insights into internalisation of its norms.

4. Results

The results of the empirical analysis are summarized in Tables A1 and A2 and are graphically presented below in Figures 1 and 2.

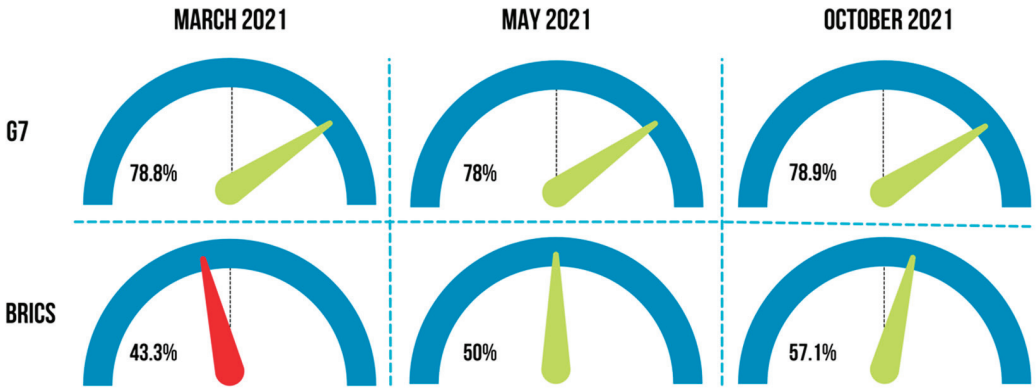

Figure 1. Proportion of clean versus dirty stimulus measures in response to COVID-19, by G7 versus BRICS countries.

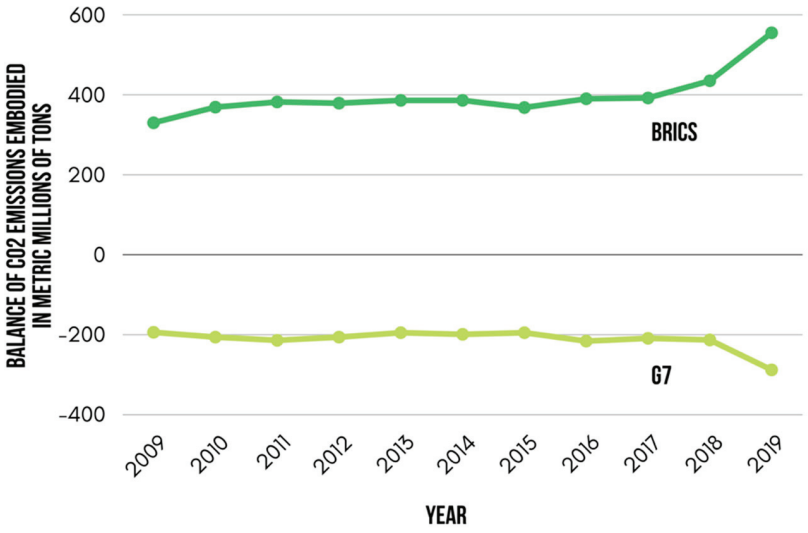

Figure 2. Balance of carbon dioxide emissions from trade: G7 vs. BRICS averages.

Figure 1 displays the proportion of clean versus dirty stimulus measures employed in response to COVID-19 by the G7 and the BRICS countries, in intervals between March and May 2021 and between May and October 2021. Aggregating by PSI, in this manner, highlights the differentiation in the proportion of clean stimulus measures employed. The proportion of green recovery measures employed by G7 members remains high at 78% at all measured intervals. Moreover, while BRICS countries had a proportionately net-dirty stimulus in March 2021, this changed to a proportionally net-clean stimulus as of May 2021, a significant move upwards. Interestingly, the trend of an increase of around 7% in the proportion of clean activities among the BRICS countries continued between May and October 2021.

Figure 2 is based on aggregated data from the Climate Tracker of the International Monetary Fund. It shows the net balance of carbon dioxide emissions that G7 and BRICS countries embodied in their international trade. It reveals that in aggregate, the BRICS countries are net carbon exporters and the G7 countries are net carbon importers. The trend lines of the BRICS and G7 appear to mirror one another suggesting that trade flows between the two trading blocs remain a large source of carbon intensive trade on a global scale. Furthermore, a nascent divergence can be seen from 2017 to 2019 which indicates the presence of a growing disparity between their respective volumes of embodied carbon emissions.

5. Discussion

The above results are intended to provide a preliminary overview of the empirical practice of the GGND as 'the new norm' and its implications for the trade–climate nexus. From it, some possible trends for norm diffusion of the GGND can be identified which are discussed in this section.

5.1. Different Speeds, Same Direction of Travel

The news headlines have suggested that the world is failing at 'building back better' from COVID-19 [46,47]. An aggregate analysis of PSIs suggests that a more subtle trend may indeed still be developing. Figure 1 indicates that both the G7 and the BRICS countries are now implementing a higher proportion of clean versus dirty stimulus measures in response to COVID-19. This could signal that state practice is now shifting from the status quo 'grey' economic recovery to a 'green' economic recovery. Notwithstanding this, the proportion is evidently higher in G7 countries. This supports the observation that the G7 has engaged more robustly with climate change as a global governance issue than other groups [48]. It also reflects the more prescient roles that climate change and green new deal policies play in the G7's Carbis Bay Communiqué [30]. The fact that climate change does not feature as a topic high on the agenda of the BRICS's summits is also reflected in their initial preference for dirty versus clean stimulus measures. However, the data for both May and October 2021 reflect a change in this, in which they are both now funding proportionally more clean measures than dirty as part of the COVID-19 response. This could be a more broad-based signal that, as the COVID-19 stimulus packages are shifting from the rescue to recovery phase in many parts of the world, they too are becoming greener. Nevertheless, Figure 1 demonstrates how there remains a proportional gap of 21.8% between the green recoveries of the G7 and the BRICS countries, as of October 2021. Importantly, Figure 1 also illustrates that the gap between the greenness of the recoveries of PSIs has indeed narrowed over the course of 2021. This reflects the fact that while PSIs may have the same direction of travel regarding a green recovery, the pursuit of this remains at different speeds.

5.2. Importance of Carbon Market Coherency in the Transition to Net-Zero Emissions

The potential that the GGND is becoming 'the new norm' faster in the G7 countries as compared with the BRICS countries, presents a dilemma due to the two group's growing divergence as net carbon importers and exporters revealed in Figure 2. While this diver-

gence exists, it is likely that strong border measures, such as carbon border adjustment mechanisms, are needed to ensure the coherency of domestic carbon markets and, concurrently, to ensure the GGND is not undermined by carbon leakage. At the same time, the norm cascade inevitably challenges the pre-existing norms at play. CBAMs may directly conflict with the norms of international trade law, such as most-favoured-nation national treatment. A prime example of the CBAM as a phenomenon is the mechanism proposed by the European Commission in July 2021. The European Commission's CBAM is designed to apply an equivalent carbon levy on imported carbon intensive goods to ensure equivalence with like domestic products that are already subject to its own Emissions Trading System [49]. In response, Russia and China have signalled that they would consider bringing a dispute on such a CBAM to the WTO [49,50]. The result of this, should it occur, will prove a key window into the success of the internalisation of the GGND's norms within global governance. Future research should assess the implications of GGND's internalisation with the carbon intensity data from 2020 onwards, particularly, to see the impact that COVID-19 had on this metric. In the meantime, these preliminary insights from the trade–climate nexus underlines the importance of carbon market coherency in the global transition to net-zero emissions.

6. Conclusions

PSIs play a key role in global governance of the GGND, with their members holding roles as both norm entrepreneurs and antipreneurs. This paper provides a novel perspective on the green recovery practice of the G7 and the BRICS countries by contrasting their direct proportion of clean versus dirty recovery stimulus. It reveals that contrary to other investigations on an aggregate or individual basis, the G7 and the BRICS countries are now implementing the same or a higher proportion of clean versus dirty stimulus measures; a proportion which changed between March 2021 and May 2021. This indicates early evidence of norm diffusion of the GGND, suggesting that it could well be a 'new norm' in global governance. While both the G7 and BRICS countries are employing the same or higher amount of clean than dirty measures as a proportion, the green recovery trend is undoubtedly clearer in both the normative rhetoric and practice of the G7. The different speeds with which both the G7 and the BRICS countries are implementing green recoveries in their 'building back better' from COVID-19 has direct implications for the future of international trade. Statistics on the emissions intensity of international trade reveal that the G7 countries are net carbon importers, and the BRICS countries are net carbon exporters. They also indicate that the divergence between the two group's net-carbon emissions from trade could well be growing. Therefore, strong border measures are needed to ensure the coherency of domestic carbon markets and, concurrently, to ensure the GGND is not undermined by carbon leakage. Consequently, while it cannot be said that the GGND is 'the new norm' in global governance yet, amongst PSIs there are nascent indications it could well be in the future.

Supplementary Materials: The following supporting information can be downloaded at: https://www.mdpi.com/article/10.3390/environsciproc2022015006/s1. Appendix A and B below provide more detail on the figures and the Data analysis worksheet is attached as Supplementary Material S1.

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Data Availability Statement: The data on which the analysis included in Appendix A are based on can be accessed here: https://recovery.smithschool.ox.ac.uk/tracking/#:~:text=The%20Global%20Recovery%20Observatory%20brings,more%20impactful%20and%20sustainable%20investment, accessed on 30 November 2021. The data on which the analysis included in Appendix B are based on can be accessed here: https://climatedata.imf.org/search?owner=climatedata_Admin, accessed on 31 July 2021.

Appendix A

Table A1. Summary of the proportion of clean to dirty stimulus measures in response to COVID-19 by PSIs, rounded to 1 decimal point.

PSI	Country	March 2021	May 2021	October 2021
G7	Germany	78.3%	78.3%	78.3%
	France	86.8%	84.6%	87%
	Canada	75.0%	87.5%	88%
	Italy	63.6%	63.6%	50%
	Japan	83.3%	83.3%	85.7%
	UK	90.0%	89.0%	90.7%
	USA	26.6%	29.2%	29.17%
	Average	78.8%	78.0%	78.9%
BRICS	Brazil	45.0%	63.6%	66.7%
	China	59.0%	65.7%	65.7%
	India	29.0%	28.6%	33.3%
	South Africa	20.0%	14.3%	63.2%
	Russia	0.0%	0.0%	0.0%
	Average	43.3%	50.0%	57.1%

Appendix B

Table A2. Balance of CO_2 emissions embodied in millions of metric tons (rounded to whole numbers).

	Country	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019
G7	Germany	−121	−127	−139	−96	−97	−105	−85	−123	−134	−150	−166
	France	−149	−150	−159	−136	−136	−140	−132	−147	−194	−223	−256
	Canada	−2	−15	−14	−10	−5	−5	10	2	9	−4	−2
	Italy	−106	−111	−106	−75−	−75	−78	−76	−59	−66	−53	−22
	Japan	−201	−217	−266	−281	−226	−213	−158	−142	−114	−48	−59
	UK	−118	−129	−126	−125	−129	−144	−143	−135	−119	−119	−126
	USA	−661	−694	−668	−718	−696	−706	−785	−910	−846	−896	−1388
	Average	−194	−206	−214	−206	−195	−199	−195	−216	−209	−213	−288
BRICS	Brazil	−45	−77	−85	−78	−81	−70	−13	−7	2	3	10
	Russia	310	317	314	235	207	233	321	321	274	225	221
	India	91	78	49	83	169	172	124	109	107	347	903
	China	1217	1432	1536	1565	1539	1484	1309	1429	1471	1488	1536
	South Africa	76	98	95	89	95	110	101	96	107	114	105
	Average	330	369	382	379	386	386	368	390	393	435	555

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The Significance of Pollination for Global Food Production and the Guarantee of Nutritional Security: A Literature Review †

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Abstract: Animal pollination is economically, socially, and culturally relevant. It is responsible for ensuring the production of biofuels, fibers, medicines, building materials, and mainly for the global production of food. The zoochorous pollination syndrome is widely discussed because of the coevolution between plants and animals; so, the pollinators have bioecological characteristics that allow several plants, mainly angiosperms, to complete their reproductive cycles. Thus, this work aims to discuss and synthesize information on studies related to the importance of pollination for global food production and the guarantee of nutritional security, one of the Objectives of the Sustainable Development goals (OSD). A narrative literary review was carried out to obtain data. Pollinators are needed to achieve several OSD, such as Zero Hunger and Life on Earth. Practical activities should be implemented to increase the survival and establishment of these organisms. The commitment of different sectors of society to pollinators is fundamental, and the lack of pollinators leads to losses in productivity and environmental quality.

Keywords: food security; OSD; zoochory

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1. Introduction

Pollination is a term that refers to the transfer of male and female gametes into plants, while pollinators are the means by which gametes travel between plants. The transport of gametes can happen by abiotic and biotic means, such as wind and rain and by the direct action of the plant or animals. The concept has transformed over the past few years to serve as a broad term for structuring a wide range of ecological interactions [1–3]. Flowering plants (angiosperms) invariably have no control over how they receive and disperse gametes [4]. However, about 87.5% of angiosperms are dependent on animal vectors for collection, transport, and pollination for reproduction [5].

Animal pollination syndrome dates back to the evolutionary past of mutually beneficial relationships between animals and plants. A long evolutionary history marks the interaction between plants and pollinators, the central hypothesis that explains the current observed ecological interactions comes from mutualistic relationships with benefits for both organisms. When searching for food (foraging), animals that can use floral resources, especially nectar, were rewarded for having access to this resource of high energy value. Over time, this meant a possible preference for certain animals with the capacity to exploit more efficient floral resources for specific plants, which allows for coevolution [6]. This process can lead to extreme ecological interaction with animals using resources unique to a certain plant species, and the plant depending exclusively on this animal for its reproduction. Plants even develop floral traits that are more attractive to animals; for example, in the case of insects, some plants have showy reflective colors at specific lengths for some pollinators, in addition to the nectar mentioned earlier.

Animal pollination is economically [7], socially, and culturally relevant; it is directly related to agriculture and food security [8]. It is responsible for ensuring the production of biofuels [9,10], fibers [7,11], medicines [12], building materials, and mainly for the global production of food [7,13], which is directly dependent on pollination and other factors such as the availability of water, nutrients, soil, and sunlight. The zoochory pollination syndrome is widely discussed due to the evolutionary period between plants and animals; so, the pollinators have bioecological characteristics that allow several plants, mainly angiosperms (±90%), to complete their reproductive cycles. In Brazil, for example, Giannini and collaborators analyzed 141 crops and found 85 dependent on pollination [14]. In 2019, a version of the Thematic Report on Pollination, Pollinators, and Food Production in Brazil of 289 foods was published, with 191 presented studies on the interaction with pollinating organisms, of which 91 presented reliable data on the need for pollinators [15]. Scientists consider that there is a lack of knowledge about the importance of plants and pollination [16], which has objective effects on humanity [8,17], (e.g., loss of production/productivity, decrease in physical and chemical quality aspects, decreased reproduction rate, among others).

Thus, this work aims to discuss and synthesize information on studies related to the importance of the pollination phenomenon for global food production and the guarantee of nutritional security, one of the objectives of sustainable development proposed by the United Nations.

Methodology

This study was carried out through a narrative literary review, collecting data/work carried out from a qualitative approach. All searches were performed in the Google Academic and Science Direct databases, using the keywords: food production AND pollinators OR global trade.

2. Current Overview of Global Food Production

The human population is growing. Projections indicate that by 2050 humanity will demand a significant increase in food production and distribution [18]. However, the land has limited space for occupation and use. Currently, 38% of the terrestrial surface is occupied by agricultural production systems, which is approximately about 5 billion hectares [19]. The productivity of the agricultural system has historically been satiated mainly through area expansion projects and the application of soil fertility conditioning inputs and application of agrochemicals to control animal and plant pests [20]. However, the increase in productive areas solely through expansion does not directly reflect an increase in agricultural productivity [21]. Furthermore, the reduction in and the fragmentation of habitats [22] reduces the resilience of the agroecosystems [23,24] and increases the emission of greenhouse gases [25,26].

Studies indicate that global agricultural production needs to grow [27,28]; estimates indicate values between 70 and 110% to meet the growing demands associated with human use and livestock feeding by the year 2050 [27,29]. Thus, researchers aim to find effective strategies to increase food production in the future [30], one of which is better production in a smaller area [31].

During the last few years, the human population has gone through exponential growth, which imposes demands for resources that, more and more, are becoming scarce. According to the Global Hunger Index, 690 million people are malnourished due to lack of adequate food and access to food [32], which implies the search for new productive areas, increasing pressure on ecosystems with the process of replacement and changes in land-use systems, which in general lead to scenarios of environmental degradation, with the reduction in natural areas and the ecosystem services provided (e.g., nutrient cycling and pollination), which in general reduce the stability of productive areas of the primary commodities and foods [33] and resilience of these areas [23].

Furthermore, the production and consumption of food have been globalized, which gives rise to the concept of virtual resources, that is, resources that are virtually added to internationally traded products.

3. Significance of the Pollinator

Pollination is an ecosystem service, which means that it is considered a consumer good and a service that benefits human beings. This service is responsible for reproducing several plants and crops that are substantially benefited directly or indirectly by pollination by animals such as bees, butterflies, bats, and birds. It is estimated that 75% of all crops profit, to varying degrees, from this type of pollination [34]. Thus, pollination enables the production of food in quantity and quality, which allows food security in several countries, especially in developing countries [35], whose economy is based on agricultural export products.

The decrease in animal pollinators causes severe consequences for the economy and ecosystems. There is a decrease in non-domesticated plants, imbalance in natural environments, decrease in food production and social welfare. The main factors are of anthropogenic origin and are mainly related to land use change, which results in the loss and fragmentation of habitats, in addition to the use of pesticides [31,32], environmental pollution, climate change, dispersal of invasive species, and diseases [36].

Recent studies show the relevance of pollination services related to the diversity of pollinating species; in the most diverse types of food crops (±70%), the volume of agricultural production dependent on animal pollination increased by 300% from 1966 to 2016 [8]. Below we highlight the main pollination-dependent crops (Table 1).

The quality of the fruit's flavor, quality, yield, and nutritional aspects may be linked to the quality of pollination. In a study with strawberries, self-pollination greatly affected production, but animal and manual pollination did not differ in terms of fruit quality. However, manual pollination is often a paid service, especially for large production areas. Hence, animal pollination attends to physiological processes that can result in cheaper fruit and a high-quality standard [37].

For other vegetables, pollination can favor various ways of maintaining the quality of the fruit, seeds, and crops [38], for example, jabuticaba (*Plinia* sp.). Even in self-compatible species for pollination, the presence and action of a pollinating organism are necessary, which allows an intensification of fruiting [39] (Figure 1), increasing its added value and productivity.

Due to removing natural areas to transform them into agricultural production areas, we have the loss of animal diversity and, within it, the pollinators. Agricultural landscapes devoid of high crop diversity imply a drastic reduction in bee species [39]. These groups, as already discussed, have different ecological roles and environmental services such as pollination of vegetables, fruits, vegetables, among others, that are of fundamental importance for the survival of humans (food) and other animals in the food chain.

According to the Food and Agriculture Organization of the United Nations [40], it is estimated that some species of bee pollinate approximately 73% of plant species cultivated in the world, 19% by flies, 6.5% by bats, 5% for wasps, 5% for beetles, 4% for birds, and 4% for butterflies and moths. Given the importance of this environmental service, beekeepers saw pollination by hives as an essential technique to increase agricultural production and an investment opportunity to rent bees for income generation purposes.

In many countries around the world, such as the USA and countries in Europe, beekeeping began to have pollination as its primary goal, a highly profitable business, making honey a byproduct. This service is an alternative to minimize the effects of the potential natural disaster of the lack of these pollinators globally, which interferes with the production of various foods. The methodology consists of transporting the hives to planting areas in times of flowering, where they can remain for a period of up to three months, ensuring more significant and better productivity [41].

Table 1. Most common food items in the world, highlighting those that depend directly or indirectly on pollination and/or benefit from pollinating organisms.

Popular Name	Scientific Name	Popular Name	Scientific Name
Coffee	*Coffea* spp.	Fig	*Ficus carica*
Soybean	*Glycine max*	Atemoya	*Annona squamosa*
Tomato	*Lycopersicon* spp.	Kiwi fruit	*Actinidia deliciosa*
Seed cotton	*Gossypium* spp.	Castor bean	*Ricinus communis*
Cocoa bean	*Theobroma cacao*	Broad bean	*Vicia faba*
Orange	*Citrus* spp.	Persimmon	*Cavanillea philippensis*
Watermelon	*Citrullus lanatus*	Kaki	*Diospyros kaki*
Passionfruit	*Passiflora edulis*	Sweet passion fruit	*Passiflora alata*
Apple	*Pyrus malus*	Quince	*Cydonia* spp.
Melonseed	*Cucumis melo*	Cow peas	*Vigna unguiculata*
Bean	*Phaseolus* spp.	Linseed	*Linum usitatissimum*
Coconut	*Cocos nucifera*	Lychee	*Litchi chinensis*
Guava	*Psidium guajava*	Bean	*Phaseolus vulgaris*
Peach	*Prunus persica*	Pomegranate	*Punica granatum*
Avocado	*Persea americana*	Cherry	*Eugenia uniflora*
Sunflower seed	*Helianthus annuus*	Surinam cherry	*Stenocalyx michelii*
Papaya	*Carica papaya*	Tree cotton	*Gossypium arboreum*
Plum	*Prunus* spp.	Cambuci	*Campomanesia phaea*
Annatto	*Bixa orellana*	Gliricídia	*Gliricidia sepium*
Tangerine	*Citrus reticulata*	Brazil nut	*Bertholletia excelsa*
Cashew nut	*Anacardium occidentale*	Macadamia	*Macadamia integrifolia*
Lemon	*Citrus* spp.	Mombin	*Spondias mombin*
Guarana	*Paullinia cupana*	Pumpkin	*Cucurbita* spp.
Groundnut	*Arachis hypogaea*	Vanilla	*Vanilla* spp.
Peppers	*Capsicum annuum*	Soursop	*Annona muricata*
Cupuaçu	*Theobroma grandiflorum*	Adesmia	*Adesmia latifolia*
Acerola	*Malpighia emarginata*	Araticum	*Annona crassiflora*
Pear	*Pyrus communis*	Apricot	*Prunus armeniaca*
Oil palm	*Elaeis guineensis*	Strawberries	*Fragaria* spp.
Almond	*Amygdalus communis*	Mango	*Mangifera indica*
Eggplant	*Solanum melongena*		

Adapted from: Klein, 2007; Giannini, et al., 2015; Reilly, Jr., et al., 2020.

Research shows that when using bees in agricultural cultivation areas, there is an increase in production, such as in apple, cherry, watermelon, pumpkin, and blueberry crops, with economic values for these productions being 1.06 billion, 177 million, 146 million, 101 million, and 50 million dollars, respectively [42]. Thus, the importance of bees for the economic valuation of crops and the need to maintain the biodiversity of pollinating organisms through the maintenance and restructuring of habitats to remain in the environment to help even more in production is noticeable.

Figure 1. African bee (*Apis mellifera* L.) consuming floral resources of jabuticabeira (*Plinia* sp.), a Brazilian fruit tree. This pollenizer in Brazil represents one of the most recurrent species in natural and anthropogenic environments. Source: Franco, A. L.

4. Final Considerations

Animal pollinators are organisms that provide essential services at ecosystem levels that directly affect the economy and human wellbeing. Thus, as much as the production and trade of food in the world involves different factors and interests, a traditional paradigm shift is necessary. There is a perception that it is utopian to aim to achieve several Sustainable Development Goals of the United Nations (Zero Hunger and Life on Land), but we are optimistic.

In order to leverage pollination services, practical activities must be implemented to increase the survival and establishment of these organisms, which include practical actions such as increasing habitats, preserving portions of natural environments, and banishing harmful pesticides. Most farmers and society generally are not aware of the socioenvironmental and economic value of pollinating agents in terms of food production and several other factors. Nevertheless, there is a need for broad dissemination programs about their importance for humanity and nature for this to be possible.

There is increasingly a scenario of commitment on the part of companies, organizations, and studies that are elucidating quantitatively and qualitatively the role of pollinators in maintaining and balancing terrestrial ecosystems for social wellbeing and the economy. The current perception is that there is much to be done. However, it is increasingly important to note that there is interest in having public and private institutional policies to preserve and pollinate organisms. The lack of these regulatory and compensatory stimuli can invariably lead to losses in productivity and environmental quality.

Supplementary Materials: The following supporting information can be downloaded at: https://www.mdpi.com/article/10.3390/environsciproc2022015007/s1, Figure S1: African bee (*Apis mellifera* L.) consuming floral resources of jabuticabeira (*Plinia* sp.), a Brazilian fruit tree. This pollenizer in Brazil represents one of the most recurrent species in natural and anthropogenic environments; Table S1: Most typical food items globally, highlighting those that depend directly or indirectly on pollination and/or benefit from pollinating organisms.

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Proceeding Paper

Perspectives on Sustainable Management of Jackfruit Trees for Food Consumption in Rio de Janeiro, Brazil †

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Abstract: Given the emerging challenges of climate change on the food system, alternative solutions that promote food security for the Brazilian population while conserving ecosystems and supporting smallholder farmers are needed. This study sought to explore the potential of one solution: the use of green jackfruit as a culinary alternative to meat. This study investigated consumer perception of jackfruit through an online survey completed by 330 individuals and through interviews with jackfruit entrepreneurs. The research highlighted a knowledge gap in Brazilians' perception of the food uses of green jackfruit and the need for a change in food culture to expand its use.

Keywords: food security; nutrition; Brazil; jackfruit; entrepreneurship; biodiversity; climate change; family agriculture; protected areas; exotic species

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1. Introduction

In the face of the daunting challenge to adequately feed the world's population, policymakers around the world are making commitments to take action, such as the United Nation's Sustainable Development Goal Two to "end hunger, achieve food security and improved nutrition and promote sustainable agriculture" by 2030. Yet transforming the food system into one capable of providing the entire population with healthy foods, while simultaneously protecting the environment and respecting the local culture, is a challenge in contemporary society. In this context, the debate on food production alternatives that are more sustainable with respect to social, environmental, and economic factors requires interdisciplinary research and action that consider the local realities and opportunities of each territory. This involves thinking about foods that grow naturally and abundantly in the ecosystems of differing regions and that are resilient to the environmental changes that accompany climate change.

This research aimed to explore an example of one such type of food, the jackfruit, which fulfills this function in a specific territory, the state of Rio de Janeiro, Brazil. Jackfruit, a fruit of the jackfruit tree (Artocarpus heterophyllus Lam.), is abundant in different regions of the country, especially in areas of the Atlantic Forest biome and on the properties of small landholder farmers. The fruit has many nutritional properties and can be used in a variety of ways in cooking, including as a culinary substitute for meat and starches when used in its unripe, non-sweet form. The jackfruit tree, in turn, has a much greater capacity to withstand the effects of climate change than large-scale crops such as wheat and corn. In fact, the jackfruit has recently been called a "miracle crop" by leading food security specialists. According to the President of the International Tropical Fruits Network, "[Jackfruit] is easy to grow. It survives pests and diseases and high temperatures. It is drought resistant. It achieves what farmers need in food production when facing a lot of challenges under climate change" [1].

At the same time, the jackfruit tree is an exotic species in Brazil that is felt by conservation professionals and managers of some protected areas to exhibit invasive or opportunistic behavior in the Atlantic Forest [2,3]. The management of jackfruit in protected areas and respective buffer zones in the state of Rio de Janeiro is a priority and a challenge for managers. Current control plans are generally based on species elimination or reduction through girdling and the use of herbicides, often producing inadequate results and creating other environmental problems [4].

Despite the jackfruit's abundance, nutritional properties, and culinary variety, the fruit is highly underutilized by the Brazilian population, especially when in its green form. In fact, the jackfruit often is perceived negatively by many individuals. With the growing vegetarian movement in Brazil, there are several entrepreneurs in Rio de Janeiro trying to change this attitude, seeking to bring jackfruit to the forefront of Brazilian gastronomy. Additionally, the sustainable management of the jackfruit trees on a large scale—especially on the outskirts or periphery of Rio de Janeiro—can not only generate income for smallholder farmers and promote food security, but also provide an alternative control method for this exotic species inside and near protected areas—"eat it to beat it", as some jackfruit entrepreneurs say.

However, to create a growing market of new consumers of green jackfruit products and promote large-scale sustainable management of the tree, it is necessary to understand why the fruit is underutilized in Brazil, especially in its green form. Currently, there is a lack of academic literature or evidence-based research that explains this underutilization, including the negative perception many Brazilians have of the fruit and the tree. This research aimed to contribute to filling this gap and better understand how residents of Rio de Janeiro perceive jackfruit, with the goal of supporting the creation of solutions by jackfruit entrepreneurs to overcome the existing barriers and promote models for sustainable jackfruit management.

2. Materials and Methods

To investigate the underutilization of green jackfruit for food consumption in Brazil, both qualitative and quantitative methods were employed to study the perception of the fruit by Brazilians in Rio de Janeiro. The research was conducted between June and September 2020 and was approved by the Research Ethics Committee of the Federal University of the State of Rio de Janeiro, under Protocol number 797/2016. Permission of the par ticipants was obtained by signing an electronic Informed Consent Form (ICF). Open interviews were conducted with three entrepreneurs from Rio de Janeiro who commercialize green jackfruit. The interviews focused on exploring the challenges of the market and consumer perception of green jackfruit from a business perspective, as well as to understand the entrepreneurs' supply chains and current business models. In addition, a semi-structured questionnaire online was answered by 330 people to evaluate various aspects of Brazilians' perceptions about and familiarity with the jackfruit tree and jackfruit as a food. The questions were divided into 3 main topics: (1) perception of the jackfruit tree, (2) per ception of the green jackfruit as food, and (3) personal data. The online questionnaire was distributed to a convenience sample, mainly to students at local universities, public servants, and associated networks of the researcher and her advisors. The results were analyzed using graphics and textual description.

3. Results

The participants in the survey came from a variety of backgrounds such as lawyers, landscapers, nutritionists, public servants, entrepreneurs, farmers, park rangers, doctors, educators, journalists, designers, therapists, and architects. The majority have backgrounds in higher education, with 35% being students or professors in academia. The age breakdown of the participants is the following: 33% were between 18 and 30 years old, 29% between 30 and 40 years old, 19% between 40 and 50 years old, and 19% over 50 years old. Only 15% of the participants were vegetarians.

Five of the survey questions related to participants' knowledge and perception of the jackfruit tree as a species. An amount of 52.4% of participants were correct in affirming that the species is native to Asia while 14.3% believe that jackfruit comes from Brazil, confirming that the tree is perceived by some as a native species. These results can be viewed graphically in Figure 1.

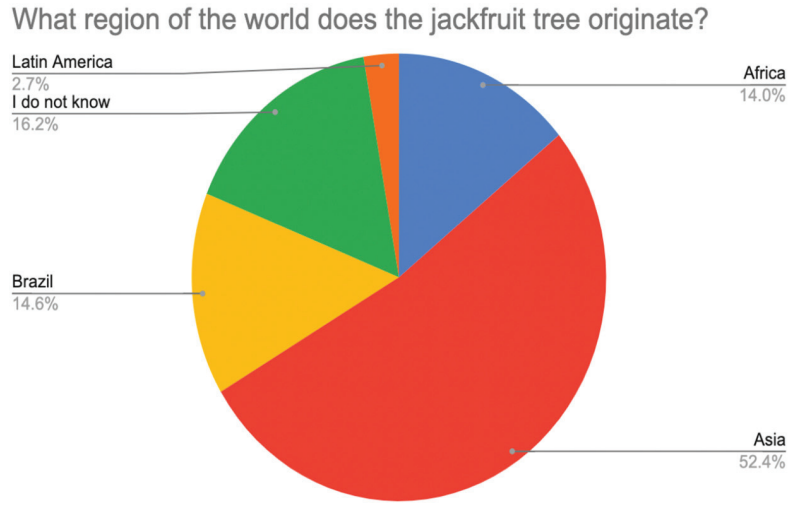

Figure 1. Graphical representation of question number 5 on the survey to assess participants' knowledge of the jackfruit tree's origin.

Regarding being considered an invasive plant, 57% disagreed that jackfruit is an invasive species and that it harms the ecosystems in which it inhabits, and only 11% believe that all jackfruit should be removed from protected areas. Of those 11% who support removal, 70% of them are biologists or ecologists. An amount of 88% of respondents believe that using jackfruit for food is better than removing trees. These answers reveal that the majority of this multidisciplinary sample perceives jackfruit as an opportunity for food consumption and is generally not aware that the jackfruit tree is considered an invasive species by many biologists and conservationists. However, biologists in the state of Rio de Janeiro mainly perceive it as a threat to biodiversity.

The questionnaire also included eight questions aimed at assessing the participants' familiarity with green jackfruit as a food. 53.9% of the participants (178 individuals) answered that they had eaten green jackfruit. Of these 178, 84.3% (150 people) responded that they liked or loved the taste of the green jackfruit. See Figure 2 for a more detailed breakdown of the responses.

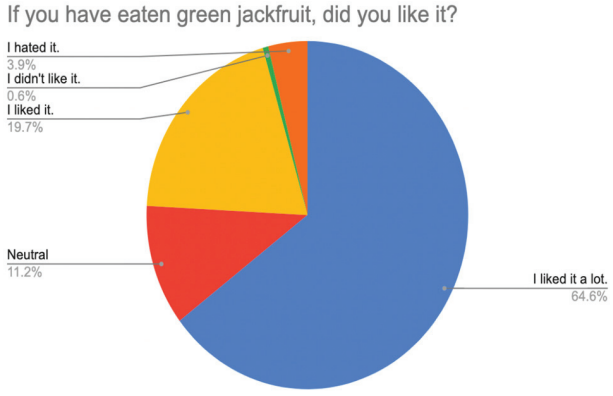

Figure 2. Graphical representation of question number 8 on the survey to assess consumer taste of green jackfruit.

In addition, only 23% of those who responded yes to having consumed green jackfruit were vegetarians. Additionally, only 14.9% of participants had prepared a meal using green jackfruit at home. Of these 48 individuals, nearly 40% responded that they believed food preparation with green jackfruit was difficult.

The survey also sought to identify which forms of jackfruit are most commonly consumed in Rio de Janeiro. The survey results reflect what had been seen in the literature, showing that the most common recipe is the jackfruit "coxinha"—a small, fried croquette. Other popular recipes mentioned by the participants included moqueca (a Brazilian stew), bacalhau, strogonoff, and empadão (a savory pie).

The interviews with jackfruit entrepreneurs in Rio de Janeiro complemented the results of the online survey, shedding insight into the historical context and current challenges around the use of jackfruit as a food. According to one entrepreneur, whose organization, Mão na Jaca, works to transform the negative perception of the fruit with workshops and small-scale commercialization, the fact that jackfruit was used, mainly in colonial times, as food for enslaved people in sugarcane, charcoal. and coffee plantations. has had consequences to this day. "The culture of using green jackfruit in savory dishes never arrived here. To feed the slave labor force, there was no interest in spreading a culinary culture. To this day, jackfruit is primarily consumed freshly ripe, or in sweets—another Portuguese heritage. However, its integral use is hampered by the exclusive consumption of the fruit when its ripe—our cultural reference for its consumption. As a result, we have a huge waste of this fruit, which is so abundant in several Brazilian cities".

Another jackfruit enterprise, located on the outskirts of Rio de Janeiro, is growing its processing production capacity with the aim to purchase jackfruits from smallholder farmers near and around protected areas for income generation and to control the spread of the exotic species. In their experience, they find that landowners and smallholder farmers who have jackfruit on their properties generally do not perceive the tree as useful, seeing it as a burden due to the excess of massive fruits that fall and rot on the ground, attracting flies and other animals. The rural landowners are generally unaware of its consumption in its green form and do not know that commercialization opportunities exist. This same enterprise has been reaching out to restaurants and food distributors to sell its jackfruit products. According to the sales director of the enterprise, while a growing number of vegetarian restaurants are beginning to use green jackfruit in their recipes, many chefs and food storeowners are skeptical about using green jackfruit, having never heard of its use in savory dishes. Those who do know it also tend to want the "shredded" jackfruit, which is only one of many parts of the fruit that can be used, demonstrating that the food market is not yet familiar with the different modalities of the product.

4. Discussion

4.1. Consumers and the Jackfruit Market in Rio de Janeiro

While this study was a preliminary descriptive study, we believe that these initial results are sufficiently positive to justify a larger scale, well designed study in the future to more definitively assess Brazilians' attitudes towards jackfruit. The fact that 53% of survey participants have consumed green jackfruit suggests that the fruit in its green form may have moderate recognition in Rio de Janeiro, at least for individuals with higher education that live in the city. Beyond this, the results of the survey also demonstrate that those who try green jackfruit generally like the taste, thereby showing the potential for its acceptability in its non-ripe form, in which the fruit is used in savory dishes, for a larger audience. Interestingly, as only 15% of participants considered themselves vegetarians, it is clear that the consumption of green jackfruit is not restricted to this subgroup. However, as most participants have a background with higher education and are therefore more likely to have a medium to high income level, it would be important to repeat the survey with a more diverse audience to understand if individuals without higher education have a similar familiarity with and acceptance of the fruit. The interviews with the entrepreneurs who work in the periphery of Rio de Janeiro—regions with generally lower income and

less educated populations—reveal that, based on their experience, familiarity with green jackfruit is low.

The present study points out that less than 15% of participants had prepared a meal at home using green jackfruit, and that of these individuals, 40% found it difficult to prepare. These data illustrate two challenges that the green jackfruit market faces. First, that the utilization of the green jackfruit in a domestic setting in the kitchen is rare, even for those that are familiar with and have consumed the product. This could be due to a lack of knowledge of how to prepare the product, as well as a lack of access to processed green jackfruit in supermarkets. The fact that many respondents found it difficult to prepare a meal with jackfruit suggests that there exists a need to create and expand the production of sub-products that are consumer-friendly and easy to prepare. In the United States, for example, it is common to find prepackaged green jackfruit that has been cooked and prepared in flavored sauces. The jackfruit entrepreneurs interviewed all reported that work shops and hands-on courses in which participants are trained in how to use the green jackfruit in recipes is essential for expanding the jackfruit market.

4.2. Understanding How Perceptions Affect Jackfruit Consumption

While the survey results indicated at least a moderate degree of familiarity with green jackfruit, the entrepreneurs interviewed conveyed that they often confront negative prejudices about jackfruit from potential buyers. One entrepreneur suggested that the historical context of the jackfruit, in which it was principally used as food for enslaved and impoverished people and always in its ripe form, has contributed to this prejudice. While there is little academic research that investigates the perception of jackfruit in Brazil, one author points out that part of this cultural prejudice in Brazil could be related to the strong smell of jackfruit when it is rotting on the ground—a smell that many Brazilians, especially in the northeast and southwest of the country, recognize and associate negatively. "One of the hypotheses raised to understand the low consumption of this fruit is its very strong characteristic aroma, which immediately leads to appreciation or rejection" [5] (p. 7). In general, most of the population only knows the possibility of consuming mature jackfruit, which is generally limited to the preparation of desserts. On the other hand, the green jackfruit has a much wider range of culinary uses than the mature one, but the majority of the population still does not know its uses in cooking. As mentioned, for the proper use of green jackfruit in gastronomy, it is necessary to process it. However, this process can be laborious—as confirmed by the survey—since the rind of the fruit is hard and produces a sticky gum [6]. It is possible that this difficulty, associated with the lack of knowledge of how to process the fruit, represents factors that discourage the consumption of green jackfruit.

Another potential barrier to more widespread consumption and sustainable use of green jackfruit that requires further research is the fact that many researchers from the field of biology and forestry perceive jackfruit as an invasive species in the Atlantic Forest of Rio de Janeiro. According to the survey results, 75% of biologists and forest engineers who responded to the online survey agree that jackfruit is an invasive species that harms the ecosystems in which it occurs. Based on the personal experiences of the jackfruit entrepreneurs, the species' reputation as a "villain" contributes to the lack of sustainable management models. Instead of perceiving the abundance of fruits as an opportunity for income generation for rural landowners and to promote food security, most control strategies focus on total removal of the trees, using techniques such as injecting herbicide or ringing. However, often these strategies are not always effective. For example, in the Tijuca National Park, "between 2000 and 2005, they cut 1571 trees and rung another 813, in addition to uprooting almost 40,000 seedlings, without any proven efficacy in terms of real reduction of jackfruit populations in the park" [4]. Beyond this, the jackfruit tree has become so common in certain parts of the Atlantic Forest in Rio de Janeiro that many fauna species depend on the fruit for their survival; therefore, radical removal can cause other imbalances in the ecosystem if not done gradually and carefully. The "eat it to

beat" management model seeks to control the spread of the species in forests through the consump tion of the fruits, preventing the hundreds of seeds from the large fruits from falling and germinating. According to the entrepreneurs, while many park managers and forest conservation policymakers are often hesitant to consider such a method for jackfruit management, some decisionmakers are open to exploring this alternative, as the need to find solutions that integrate human communities within and around protected areas with conservation is growing. However, for policy change to occur, it is essential that more research be conducted on the alternative management method—fruit collection as opposed to tree ringing or use of herbicides—and investigate if such a model can effectively promote control of the species and therefore biodiversity conservation.

4.3. Success Cases of Sustainable Jackfruit Management

One of the entrepreneurs interviewed for the study has created a small but successful example of how jackfruit trees in a protected area can be managed by local communities and used to generate income for the residents. Vale Encantado, in Alto da Boa Vista, a community in the buffer zone of the Tijuca National Park, is known for its use of green jackfruit for culinary use, serving dishes at its ecotourism restaurant and selling processed jackfruit to restaurants in Rio de Janeiro. The 140 residents of the community are descendants of workers from the 19th century coffee farms that occupied the mountainous slopes of the area, which is now Parque da Tijuca [7]. In 2005, the president of the Homeowners' Association, with support from a French NGO, ABA-QUAR/PARIS, founded a sustainable ecotourism cooperative in which he became president. Promoting trails and other experiences in the forest, the cooperative also created a restaurant for visitors that serves dishes that use local ingredients, including jackfruit, whose harvest already exists in the culture of extractivism in the community. The "jacalhau" dish (inspired by the traditional Brazilian cod recipe) and jackfruit pies served at the restaurant have gained fame in the city.

This cooperative started selling processed green jackfruit to several restaurants in Rio de Janeiro. According to the interview with the president of the Cooperative, in 2019 the cooperative processed 600 jackfruits in total, each jackfruit weighing between 7 and 15 kg, extracted from 30 trees. Based on these numbers, the cooperative sold approximately 6 tons of jackfruit in 2019. The project employs 10 women from the community in the processing center and 4 men for collecting the fruits. The Vale Encantado model is an example of jackfruit management in protected areas that uses jackfruit as food and promotes income generation for residents in the protected area's buffer zone. This case can serve as an inspirational model for other commercial jackfruit initiatives in Brazil that generate a positive socio-environmental impact close to environmentally protected areas. As mentioned, it would be important to study the impact on biodiversity and other ecosystem factors in this model in order to create a better dialogue with forest conservation policy makers in regard to exotic species control.

4.4. Jackfruit for Food Security and Nutrition in the Context of Climate Change

While exploring alternatives to exotic species control is one important aspect of potential benefits of jackfruit consumption, the primary area in which this research focuses is how its use as a food source can contribute as a solution to promoting food security and nutrition in the context of climate change. Due to its abundance, high level of nutrition, and ability to reproduce in different climatic conditions, jackfruit is being called the "miracle crop" by researchers in the field of food security and is being seen as a food with great potential for the agricultural challenges that are emerging from climate change [8]. Climate change will accelerate food shortage risks; inconsistent rains, droughts, increased temperatures will occur, and already has reduced yields from cash crops such as corn, wheat, and soybeans—on which both humans and livestock animals depend [9]. The soil is deteriorating between 10 and 100 times faster than it is being formed in the world, threatening the fertility of land for growing food [9]. Higher concentrations of carbon dioxide in the atmosphere will also reduce the nutritional quality of food, while the increase in temperature reduces crop

yields and harms livestock [9]. Climate change can lead to shortages in food production in developing countries, impacting disproportionately small farmers and the most vulnerable populations. Brazil is an agricultural country, dependent on the export of these cash crops that are being threatened by climate change, and on small farmer production for the country's internal consumption.

There is a growing global need to take advantage of locally produced food that grows naturally and abundantly and is resilient to environmental changes resulting from the climate crisis. In Brazil, jackfruit shows the potential to be one of these foods. Its resilient qualities together with its abundance of yield make jackfruit a promising alternative to more fragile crops in the rapidly changing global climate. Jackfruit is drought-resistant, grows easily in degraded soils, and doesn't require pesticides. Indian researchers have also recognized the fruit's great potential to alleviate world hunger, emphasizing the fruit's caloric and nutritional density According to Shyamala Reddy of the University of Agriculture and Science in Bangalore, India, "It's a miracle that it can provide both nutrients and calories, everything; If you eat just 10 or 12 segments of this fruit, you won't need food for the other half of the day" [1].

This caloric and nutritional density, combined with the plant's resilience to changing climate factors and its abundance in Brazil, makes jackfruit a suitable food to contribute to food security in the context of climate change and environmental and economic crises. Indeed, the importance of accessing local, abundant, and resilient foods such as jackfruit has been highlighted in the new context of the worldwide COVID-19 pandemic. The pandemic is impacting the global food system, especially as movement restrictions between and within countries disrupt entire food supply chains, logistic services, and agricultural workers, affecting food availability. The pandemic and economic crisis is causing a decrease in income, an increase in the unemployment rate, and even a reduction in informal work, putting the most vulnerable populations and those with low purchasing power at risk of worsening food insecurity [10].

Jackfruit is already being used as a solution in this context, as seen in India, where demand for jackfruit has soared since the lockdown in late March 2021: "Coronavirus caused fear of chicken and people switched to jackfruit. In Kerala, the blockade caused an increase in demand for green jackfruit and seeds due to shortage of vegetables with border restrictions" [11]. In the context of COVID in Brazil, where now "tens of millions of people living in poverty are again facing hunger", jackfruit could also function as a possible means to combat food insecurity in this crisis [12]. The urban and peri-urban areas of the state of Rio de Janeiro are full of jackfruit trees, and these could provide healthy, low-cost food for people in peripheral communities who face food supply difficulties.

The jackfruit's nutrition, culinary variability, and resilience to climate change, in addition to its abundance in the country, make it a fruit with a large potential in becoming an alternative, healthy food source in Brazil. However, if Brazil wants to take advantage of this opportunity, it will have to invest in green jackfruit production models to achieve scale and impact, as well as, importantly, as shown by this study, support jackfruit entrepreneurs in transforming the negative perception and/or lack of knowledge of jackfruit by potential consumers.

5. Conclusions

Academic research that explores the underutilization of this abundant and highly nutritious fruit in Brazil is still in its infancy. This study sought to fill this knowledge gap by attempting to better understand Brazilians' perception of jackfruit and the jackfruit tree, recognizing that a cultural dietary change is necessary to make possible the expanded use of green jackfruit as a food in the Brazilian diet. Future larger scale studies that include a more representative sample of the population can more definitely examine the issue.

Moreover, the research highlighted one example of a successful green jackfruit venture in Rio de Janeiro that has been able to, on a small scale, manage jackfruit trees in a protected area of forest while providing healthy food and generating income for the local community.

This business can serve as a model for enterprises based on jackfruit management for food consumption, as well as for policymakers in forest conservation and food policy to learn and study the potential for replication of such a model.

The authors hope that, soon, the management of jackfruit for food consumption will not be just an "alternative" practice, but a mainstream part of the diet so that every Brazilian grows up eating jackfruit where it is abundant, and each jackfruit is part of the balance of nature in the forest of the Atlantic Forest biome.

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Proceeding Paper

Impact of Land Use and Land Cover Changes on the Stream Flow and Water Quality of Big Creek Lake Watershed South Alabama, USA †

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Abstract: Land use is one of the key factors affecting the stream flow of a watershed. This research aimed to evaluate the impact of changing land use and land cover (LULC) on stream flow and water quality by applying the Soil and Water Assessment Tool (SWAT) to the Big Creek Lake watershed located in Mobile County, South Alabama. Digital elevation model (DEM), LULC data, weather data, soil data, observed streamflow, nitrogen, and phosphors data were used as input files to calibrate and validate the SWAT model. The SWAT model was calibrated and validated using the Sequential Uncertainty Fitting (SUFI-2) algorithm in the SWAT Calibration Uncertainties Program (SWAT-CUP) software. Agricultural land increased by about 11,045 acres and urban area increased by 3350 acres, and forest area decreased by 11,482 acres, between 1991 and 2020. This changing scenario of LULC not only increased the streamflow but also the total nitrogen and phosphorus. The total streamflow was higher, at about 38 m^3/s in the LU_2020 scenario, than in the LU_1990 scenario. Increases of about 1,136,919 kg of nitrogen and 324,467 kg of phosphorus were found from 1990 to 2020, and these increases can be explained by an increase in agricultural land of about 11,045 acres. The results obtained in this study are able to provide guidance to water resource management and planning for policymakers and water managers in Mobile County.

Keywords: LULC; DEM; SWAT; SUFI-2

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1. Introduction

According to [1–3] in recent decades, hydrological responses to the changing environment have become a research interest area. Changing land use and land cover (LULC) influence runoff–rainfall processes by affecting the surface components such as evapotranspiration, infiltration, and percolation. Various types of land use have different reflectivity (albedo), roughness, leaf areas, and soil depth, which impacts the land–surface interactions by affecting temperature, humidity, wind speed, and precipitation [4–6]. Changes in LULC will have an impact on these interactions, resulting in differences in surface moisture, heat, and momentum fluxes [7,8]. According to [9], local, regional, and global climate and hydrological processes depend on the spatial distribution, size, extent, and location of land cover changes. Though many investigations have focused on the hydrological response due to changes in land use [10–13], the relationship between changing land use and the hydrological response deserves more investigation. The use of hydrological models is essential because of the effective planning of water resources and protection under changing environmental conditions, and models can simulate flow regimes under different scenarios. Many of these hydrological models are applied for runoff, sediment yield, and soil loss prediction. Among all these models, the SWAT model is the most widely used and has been applied in different areas to analyze numerous problems of hydrology and water quality,

including the potential changes to the streamflow under different climate scenarios [14]. The SWAT model has achieved worldwide recognition because it is utilized to evaluate water and sediment yield and water quality parameters under present conditions, management practices, and future climate conditions with spatial and temporal resolutions that depend on the data availability [15].

2. Materials and Methods

2.1. Study Area

Big Creek Lake has an area of 3600 acres and is a tributary-storage reservoir in Mobile County, located in southwest Alabama. Although the area of the lake itself is only 3600 acres, the watershed draining into it covers approximately 65,920 acres or 103 square miles [16,17]. Although Big Creek Lake watershed encompasses large areas in Mobile County, no large municipalities exist within the watershed; however, there are several smaller towns, including Wilmer and Semmes, located within the watershed boundaries. Figure 1 shows the location of the watershed, and the weather and water quality data stations. Big Creek Lake watershed lies within the Southern Hills District of the East Gulf Coastal Plain section of the Coastal Plain Physiographic Province in close proximity to the Gulf Coast. The Gulf of Mexico influences the subtropical climate of the watershed.

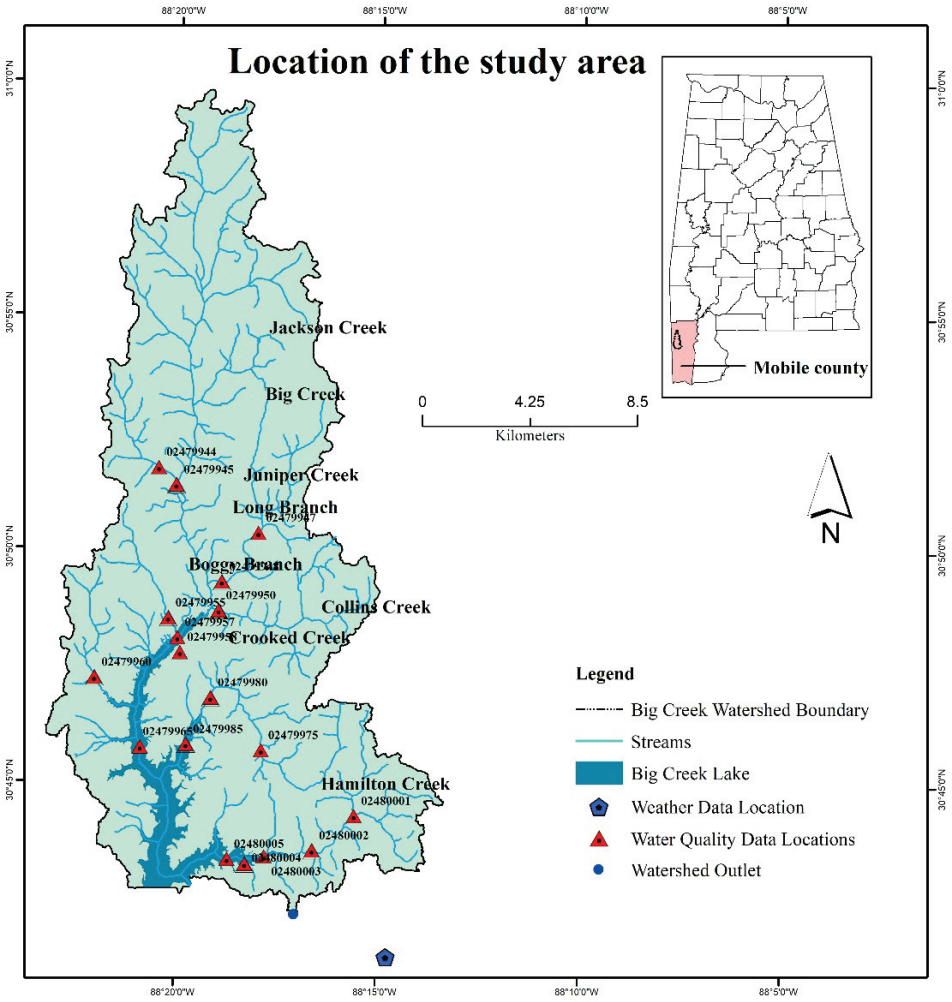

Figure 1. Location of the study area.

2.2. Data Required

Some spatial inputs are required to run the Soil Water Assessment Tool (SWAT) model, such as a digital elevation model (DEM) and associated topography, LULC, and soils of

the study area [18,19]. In addition to these inputs, long-term weather data, soil property data, and discharge data are also necessary. The USGS National Map was the provider of the DEM datasets, which were downloaded from https://viewer.nationalmap.gov/basic/ (accessed on 28 March 2020). The spatial resolution is 10 m, which is a 1 arc-second (10 m × 10 m) pixel resolution. For LULC data, Landsat images obtained from the USGS data hub (https://earthexplorer.usgs.gov/ (accessed on 4 April 2020)) and same-seasonal images were chosen from 1990 to 2020 with minimum cloud cover to have the lowest atmospheric effects. Each LULC product was primarily based upon the classification of Landsat data. Classification was performed using the unsupervised approach. The resulting classification was then reclassified into water, forest, urban, agriculture, and rangeland. The SSURGO (Soil Survey Geographic Database) soil data were used because, according to the Natural Resource Conservation Service (NRCS), the SSURGO is the county soil data having the most detailed level. The soil data and information on related soil properties were obtained from https://websoilsurvey.sc.egov.usda.gov/App/WebSoilSurvey.aspx (accessed on 11 May 2020). From the National Oceanic and Atmospheric Administrations (NOAA) website, the daily rainfall, maximum and minimum temperatures, and average wind speed at one weather station in the study were obtained between 1990 and 2020. The daily stream flow data were obtained from the USGS National Water Information System: Web Interface. Water quality data are not available in daily or monthly intervals; rather its reporting is random.

2.3. SWAT Model Description

The SWAT is a physically based hydrologic model and requires physically based data [20]. The SWAT is a continuous-time, spatially distributed model designed to simulate water, sediment, nutrient, and pesticide transport at a catchment scale on a daily time step under different management practices [21]. Arc-SWAT is an extension of ArcGIS, as the SWAT is embedded in a GIS interface. SWAT2012 is evolved from AVSWAT, which is an extension of ArcView developed for an earlier version of SWAT2012. Some major components are used to run the SWAT model including weather, hydrology, different types of soil, plant growth, nutrients, pesticides, bacteria and pathogens, land use, and management practices. When running the SWAT model, a watershed or basin is divided into multiple sub-basins or sub-watersheds, and then each sub-basin or sub-watershed is further subdivided into multiple HRUs based on the DEM properties. HRUs are located in the sub-basin and comprise unique land use, soil, and slope characteristics. The Soil Conservation Services (SCS) curve number procedure (SCS, 1972) and Green and Ampt infiltration method (1911) are the two methods used by the SWAT model to estimate the surface runoff. In this study, the SCS curve number method was used to estimate surface runoff. Water is routed through the channel network using a variable storage routing method or the Muskingum routing method. In this study, Muskingum routing methods were used for surface runoff. Briefly, the SWAT partitions soil nitrogen (N) into five different N pools. Two of the pools are inorganic (ammonium-N [NH4-N] and nitrate-N [NO3-N]) and three pools are organic (active, stable, and fresh). Unlike N, soil phosphorous (P) in SWAT is divided into six pools (three minerals and three organics). The fresh organic phosphorus pool, and active and stable organic pool, are contributed to by the crop residue, and biomass and humus substances, respectively. The soil inorganic pool includes active, solution, and stable pools [22].

2.4. Uncertainty and Sensitivity Analysis

Sensitivity analysis is the identification of the sensitive parameters that have an important influence on the performance of the model, to ensure that adjustments will be precise. This operation was carried out using SWAT-CUP. This program was developed by the Swiss Federal Institute of Water Science and Technology (EAWAG), which specializes in SWAT calibration, validation, and uncertainty analysis. SWAT-CUP is a standalone program that links to SWAT's output text files, and integrates five different optimization al-

gorithms: Sequential Uncertainty Fitting (SUFI-2) [23], Generalized Likelihood Uncertainty Estimation (GLUE) [24], Parameter Solution (ParaSol) [25], Markov chain Monte Carlo (MCMC) [26–28], and Particle Swarm Optimization (PSO) [9]. Among these algorithms, SUFI-2 has the capacity to account for all the sources of uncertainty in the parameter ranges, such as uncertainty in driving variables (e.g., rainfall), conceptual model, parameters, and measured data [23]. For this reason, SUFI-2 was used in this study to analyze the sensitivity of the model.

2.5. SWAT Model Calibration, Validation and Evaluation

The calibration of the hydrological model is undertaken to optimize its predictive capacity by comparing its simulated values with the observed or actual values of the study area. Validation is the process of demonstrating the capability of making a sufficiently accurate simulation, which may vary based on the aim of a project [29]. In this study, a five-year warm-up period, that is, from 1986 to 1990, was used. The calibration and validation periods were equal for stream flow, nitrogen, and phosphorus. Predicted and observed values of streamflow and nutrient loadings at the watershed outlet were compared to determine whether the objective function satisfactorily involves running a model using the parameters during the calibration. The results from the different periods of calibration were compared to determine whether the model meets confidence limits. The model validation was performed with the same SWAT parameter values calibrated without any further alterations. The performance of the model in the simulation was evaluated by Nash–Sutcliffe Efficiency (NSE), Percent of Bias (PBIAS), and the Coefficient of Correlation (R^2), which are most commonly used and are proposed [30].

3. Results

3.1. Land Use and Land Cover (LULC) Change

Figure 2 shows the land use over the period. Forest was one of the main land uses of the watershed and achieved a large percentage. From 1990 to 2000, almost 60% of the watershed area was forest land. However, after one decade (2010), forest area was reduced by about 10%. A total of 11,482.80 acres of forest area were transformed into other LULC categories over a 30-year period. By comparison, urban areas increased (3350 acres) in the past three decades, showing an increment of 1293 acres from 1990 to 2000, 632 acres from 2000 to 2010, and 1423 acres from 2010 to 2020. Agricultural land increased (11,045 acres) and rangeland decreased (2542 acres) in the last three decades. From 1990 to 2000, agricultural land increased, but from 2000 to 2010 it decreased, and, in the last decade, it increased by about 10,510 acres. The LULC time series analysis between 1990 and 2020 indicates an expansion in the agricultural land and an increase in urban area, with a reduction in forest land and rangeland. Forest area changed to rangeland and urban areas, by approximately 8086 and 3905 acres, respectively, in the last three decades. Agricultural land transformed into rangeland (852 acres) and urban area (674 acres), mostly from 1990 to 2020. Meanwhile, during the same period, rangeland changed into the agricultural area (5380 acres) and urban area (2080 acres).

3.2. Sensitivity Analysis

Table 1 represents the fifteen parameters used to calibrate and validate the stream flow. Based on sensitivity analysis, fifteen parameters were used, such as curve number (CN), biological mixing efficiency (BIOMIX), Manning's "n" value for overland flow (OV_N), peak rate adjustment factor (PRF), exponent parameter for calculating sediment re-entrained in channel sediment routing (SPEXP), USPE equation (USLE_P), plant and soil evaporation factor (ESCO and EPCO), and groundwater (ALPHA_BF, GW_DELAY, GW_REVAP, and RCHRG_DP). SOL_LABP, SOL_ORGP, LAT_ORGN, and SOL_ORGN were used to calibrate the nitrogen and phosphorus flow in the watershed.

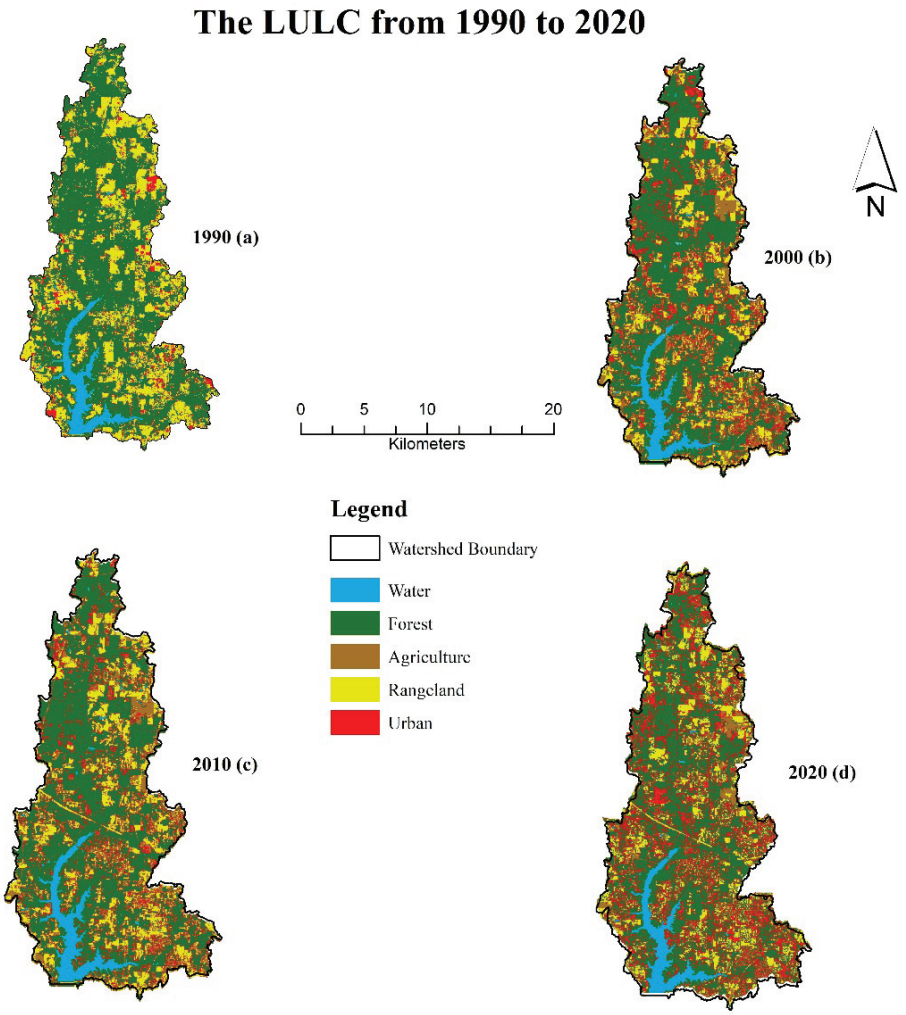

Figure 2. LULC for 1990 (**a**), 2000 (**b**), 2010 (**c**), and 2020 (**d**).

Table 2 ranks the parameters based on the t-stat and p-value, using the highest absolute value of the t-stat and the lowest value of the p-value, the highest influence of that parameter, and vice versa. Based on these values, SOL_AWC, OV_N, and RCHRG_DP are the most effective parameters, and ESCO, ULSE_P, and BIOMIX have less impact on the calibration and validation of the model.

3.3. SWAT Model Calibration and Validation

Figure 3A–C show the observed and simulated monthly stream flow, total nitrogen, and phosphorus, respectively. The differences in the average monthly observed and simulated values of stream flow were less than 1%. The R^2, NSE, and PBIAS values for streamflow for the calibration and validation periods are listed in Table 3. Based on the classified value stated by Moriasi et al. (2015), the SWAT model showed a very good level in the NSE for calibration (0.77) and validation (0.73). Adjustment between the observed, calibrated, and validated stream flow reached a good level, having an R^2 of 0.81 for both calibration and validation. A good classification was obtained for PBIAS, with values of 10.7% and 15.4% for calibration and validation, respectively. According to the classification by Moriasi et al. (2007), the SWAT model calibrated and validated the nitrogen and phosphorus satisfactorily in the determination coefficient (Table 3).

Table 1. Model parameters and their descriptions in surface flow, total nitrogen, and phosphorus calculations.

Parameter	Parameter Description	Fitted Value	Minimum Value	Maximum Value
ADJ_PKR	Peak rate adjustment factor for sediment routing in sub watershed	2	0.5	2
ALPHA_BF	Baseflow alpha factor (days)	0.1	0	1
BIOMIX	Biological mixing efficiency	0.2	0	1
CN	Curve number	Decrease 20%	35	98
EPCO	Plant evaporation compensation factor	0.95	0	1
ESCO	Soil evaporation compensation factor	1	0	1
GW_DELAY	Groundwater delay time (days)	20	0	500
GW_REVAP	Groundwater "revap" coefficient	0.02	0.02	0.2
OV_N	Manning's "n" value for overland flow "n" value for overland flow	1	0.01	30
PRF	Peak rate adjustment factor for sediment routing in the main channel	1	0	1
RCHRG_DP	Deep aquifer percolation factor	0.05	0	1
SOL_AWC	Available water capacity of soil layer	0.7	0	1
SOL_K	Saturated hydraulic conductivity	0.2	0	2000
SPEXP	Exponent parameter for calculating sediment retrained in channel sediment routing	1.5	1	1.5
USLE_P	USLE equation support practice factor	1	0	1
SOL_LABP	Initial soluble P concentration in sol layer	0.01	0	100
SOL_ORGP	Initial organic P concentration in sol layer	0.01	0	100
LAT_ORGN	Organic N in the baseflow	0.01	0	200
SOL_ORGN	Initial organic N concentration in the soil layer	0.01	0	10

Table 2. Sensitive parameters ranking based on t-Stat and *p*-Value.

Parameter Name	t-Stat	*p*-Value	Parameter Name	t-Stat	*p*-Value
r__ESCO.bsn	−0.215278727	0.829640698	r__EPCO.bsn	1.115696614	0.265105646
r__USLE_P.mgt	−0.226950855	0.820557782	r__CN2.mgt	−1.333777787	0.18290399
r__BIOMIX.mgt	0.227096486	0.820444606	r__ADJ_PKR.bsn	−1.443612737	0.149494876
r__ALPHA_BF.gw	−0.278863619	0.780468599	r__PRF_BSN.bsn	−1.948062549	0.051985146
r__SOL_K().sol	0.671455455	0.502250766	r__RCHRG_DP.gw	−1.994993478	0.046603828
r__GW_REVAP.gw	−0.728852367	0.466444494	r__OV_N.hru	−2.862365089	0.004387183
r__GW_DELAY.gw	0.846668373	0.39759842	r__SOL_AWC().sol	−38.3178933	0
r__SPEXP.bsn	−0.969346487	0.332856487	-	-	-

Table 3. Statistical evaluation of the model for calibration and validation time periods.

	R^2		NSE		PBIAS	
	Calibration	Validation	Calibration	Validation	Calibration	Validation
Stream Flow	0.81	0.81	0.77	0.73	−10.7	15.4
Nitrogen	0.75	0.77	0.62	0.65	9.34	−3.45
Phosphorus	0.5	0.54	0.34	0.24	−20.45	−21.76

3.4. Stream Flow, Nitrogen, Phosphorus of Different LU Scenarios

The relationship between stream flow and LULC, nitrogen and LULC, and phosphorus and LULC is shown by Figure 4A–C respectively. The effect of the stream flow, nitrogen, and phosphorus was estimated for the 30-year study period (1990–2020) by running the LU_1990, LU_2000, LU_2010, and LU_2020 scenarios. The greatest differences in the total stream flow between LU_1990 and LU_2000, and between LU_2010 and LU_2020, were decreases of around 12 and 21 m^3/s, respectively. These differences from 1990 to 2000 were characterized by increasing urban area and agricultural land by 1293 and 894 acres, respectively, and increasing stream flows from 2010 to 2020 were influenced by increasing

agricultural land and urban area, by 10,510 acres and 1423 acres, respectively. Moreover, comparing LU_1990 and LU_2020, total monthly stream flow increased about 38 m^3/s, which can be explained by changes in LULC, namely, increasing agricultural land by 11,045 acres and urban area by 3350 acres. Moreover, the same behavior was noticed in the stream flow between LU_2000 and LU_2010, by increasing stream flow by about 5 m^3/s. Both nitrogen and phosphorus had an increasing trend over the last three decades. From 1990 to 2020, nitrogen increased by 1,136,919 kg, and from 2010 to 2020, nitrogen increased by 768,893 kg; these increases can be explained by the increase in agricultural land, by about 11,045 and 10,510 acres. respectively. From 1990 to 2020, phosphorus increased by 324,467 kg, and most of the increase in phosphorus (around 253,975 kg) occurred in the past decade (2010–2020) (Figure 4B,C).

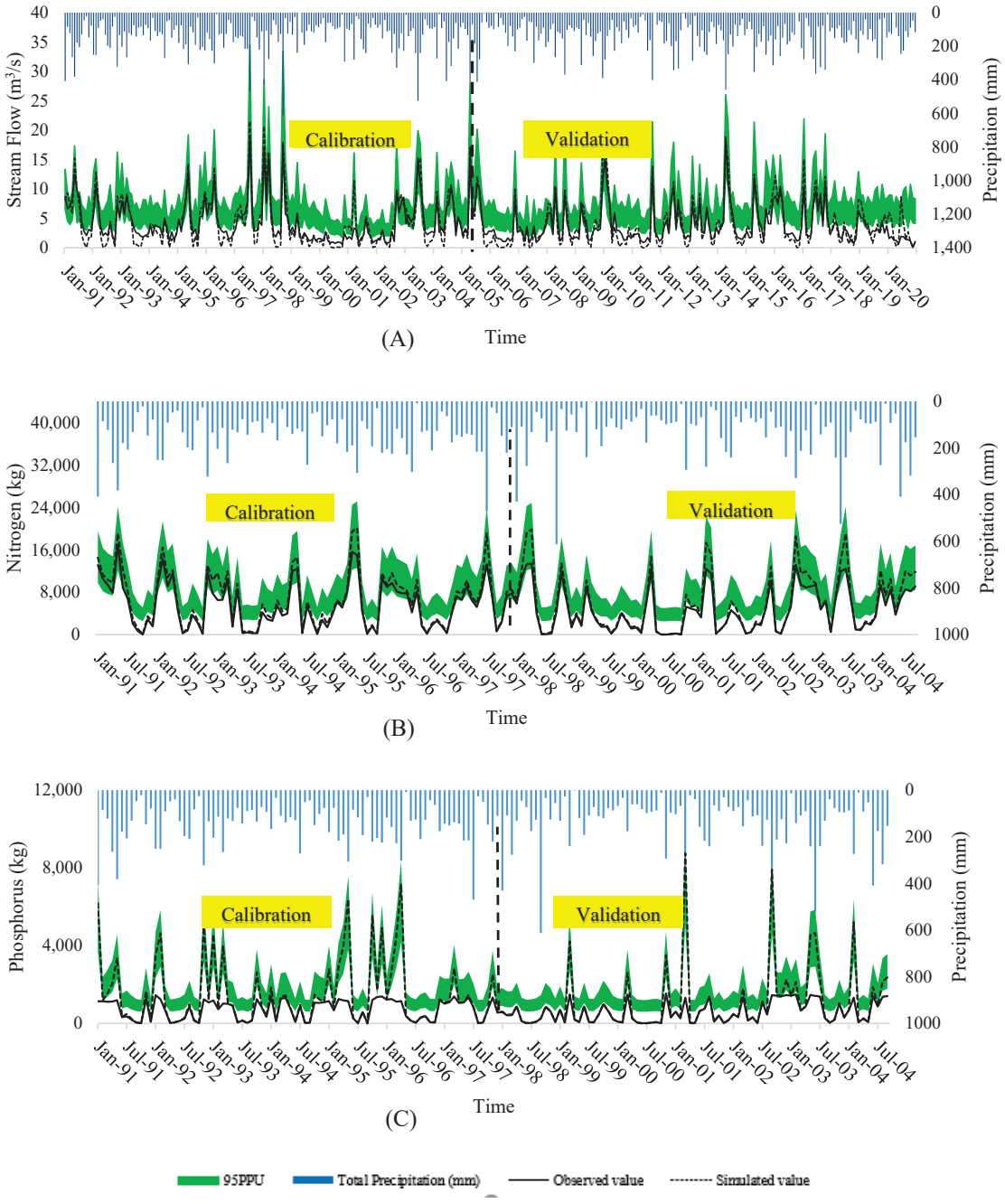

Figure 3. Observed vs. simulated stream flow (m^3/s) from 1991 to 2020 (**A**), total nitrogen (Kg/Ha) from 1991 to 2004 (**B**), and total phosphorus (Kg/Ha) (**C**) from 1991 to 2004.

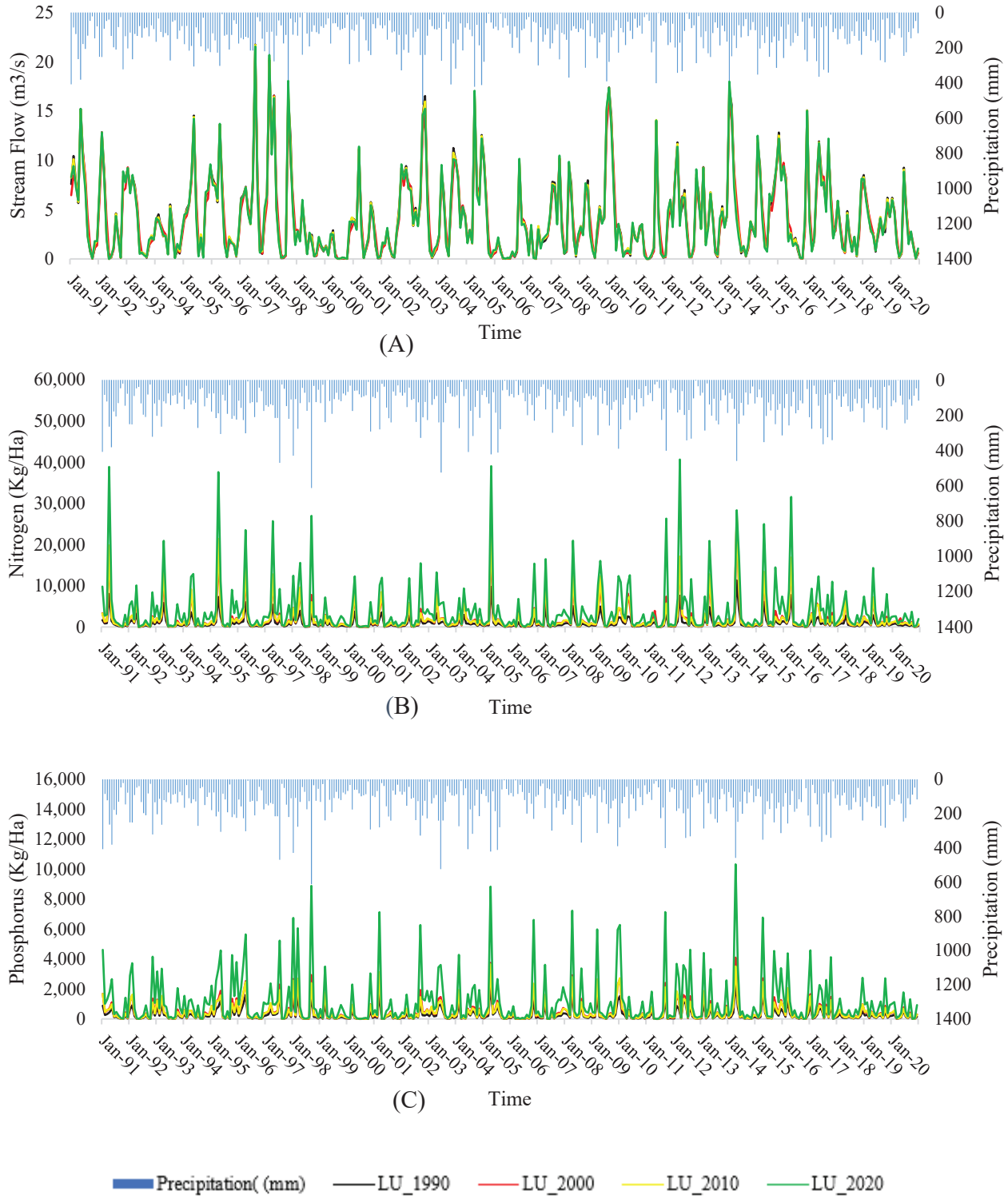

Figure 4. Simulated monthly flow (m^3/s) (**A**), total nitrogen (Kg/Ha) (**B**), and total phosphorus (Kg/Ha) (**C**) between 1991 and 2020 for different LULC scenarios (LU_1900, LU_2000, LU_2010, and LU_2020).

4. Discussion

This study shows that changes in LULC that occurred from 1990 to 2020 in the Big Creek Lake watershed were characterized by a substantial increase in agricultural land and expansion of the urban area. These results complement the study of the comparison of

temporal images of LULC for the watershed conducted by [16]. This study found that an urban area expansion occurred, and the percentage increase in high and low residential areas was 2.3% and 10.1%, respectively. According to [17], the percentage of agricultural lands is highest in the Crooked Creek sub-basin, accounting for over 41% of the sub-basin. Much of the land in the sub-basin is designated as row crops. Hamilton Creek has also the highest percentage of agricultural land (36.1%). Potential sources of nutrients in the Big Creek Lake watershed are from nonpoint contributions associated with fertilizer applications on agricultural and residential land, livestock wastes, residential runoff, failing septic systems, and contaminated groundwater. No known point sources are located in the Big Creek Lake watershed. According to [17], the total annual nutrient loads at Big Creek Lake for the 1991 water year were 118,000 kg for total nitrogen and 5245 kg for total phosphorus. As population growth continues, and hence the conversion of forested areas to agriculture and urban areas, loadings of nutrients are expected to increase because most of the land is converted to urban areas. A study conducted by [15] and prepared in cooperation with MAWSS concluded that total nitrogen (except for Long Branch), total Kjeldahl nitrogen (except for Hamilton Creek), total organic nitrogen (except for Boggy Branch), ammonia (except for Long Branch), total inorganic nitrogen, and total phosphorus (except for Long and Boggy Branches) exhibited significant, positive relationships with streamflow, which indicate the dominant source of nutrient input to the watershed is from nonpoint sources. The more residential and agricultural sub-basins of Crooked Creek and Hamilton Creek, however, yielded over twice the total phosphorus per hectare of land use. Crooked and Hamilton Creek sub-basins also had higher total inorganic nitrogen yields. These results complement the present study, which found that, over time, the stream flow increases with the increase in total nitrogen and phosphorus. This increasing nature has a positive relationship with the increase in agricultural land and urban areas. A significant, positive relationship between streamflow and nutrient concentration indicates that nonpoint sources are the dominant source of the inputs. Different land-use practices contribute different levels of nutrients by nonpoint sources.

5. Conclusions

The SWAT model is highly significant and useful because it can be used to predict future hydrological responses. The total stream flow grew by 38 m^3/s, and total nitrogen and phosphorus increased by about 113,619 and 324,467 kg, respectively, over the past three decades. This study quantified the impact of the changes in LULC on the water balance components and water quality. The results can be used by decision makers and public policy makers for future projections in terms of LULC changes.

Author Contributions: Conceptualization, E.A.E.; methodology, E.A.E.; software, E.A.E.; validation, E.A.E.; formal analysis, E.A.E.; data curation, E.A.E.; writing—original draft preparation, E.A.E.; writing—review and editing, E.A.E. and L.J.M.; visualization, E.A.E.; supervision, L.J.M. All authors have read and agreed to the published version of the manuscript.

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Proceeding Paper

Jatropha Farm: A Circular Economy Proposal for the Non-Toxic Physic Nut Crop in Mexico †

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Abstract: *Jatropha curcas* (physic nut) is a promising crop in tropical countries because its seeds have a high oil content that can be easily transformed into biodiesel. The oil can also serve to obtain other bioproducts. However, several obstacles hinder the extensive application of the crop, for example, the relative low prices of petroleum and oil, the toxicity of the seeds, low crop yields and rusticity of the plant. We propose a model in which several biotechnological strategies are applied to increase the crop value of *Jatropha*, while maintaining the fertility characteristics of the soil, and reducing its carbon and water footprints.

Keywords: *Jatropha*; oil; biodiesel; bioproducts; biofertilizers; recycling

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1. Introduction

Jatropha curcas L. (physic nut) is an emergent crop with potential utilization for biofuel synthesis. Specifically, its oil can be easily converted into biodiesel through transesterification. Glycerin is a secondary product of the process [1]. Several characteristics make this plant a future ally in the world's decarbonization efforts. The plant develops well in dry places, with poor soils, and has good resistance to pests [2]. Despite that, some concerns have arisen regarding the ecological costs of soil conversion for the *Jatropha* crop [3]. Currently, more than 1 million hectares of *Jatropha* are planted around the world. A study found that 40% of the utilized surface was previously cleared from vegetation resulting of logging, not related to *Jatropha*, 34% was defined as unused and the remainder areas were from animal husbandry or other crops [3]. In Mexico, a recognized center of origin of the plant, the agricultural surface occupied by *Jatropha* is very small [4]. The high and medium yield crop potentials in the states of Gulf of Mexico and those in the Pacific coasts are well known. The best altitudes for the crop are at sea level, with a limit at 1000 m [5].

The toxicity of the plant and seeds are factors preventing a wider use. The presence of phorbol esters in the seeds, as also curcins, is responsible for seed toxicity [6]. After oil extraction, a significant proportion of the biomass (up to 50%), known as seed cake, must be carefully treated and discarded. As a way to achieve a more complete utilization of the seeds, a project in the National University of Mexico developed years ago, led by Dr. Ivonne Toledo, consisted in the search and selection of non-toxic *Jatropha* lines across the country. Many accessions were tested and some of them were found with undetectable levels of phorbol esters (Toledo et al., unpublished results). A line named Tlaxcala-2, with such a characteristic, was selected to be included in a pilot project. A total of 30 fields scattered in the south of the Morelos state (in central Mexico, 1000 m a.s.l. altitude on average, moderate-to-low rain precipitations) were established in 2015, covering around 30 hectares, with around 20 thousand plants of the Tlaxcala-2 type. The plants are now five

years of age. In this project, we propose the application of five biotechnological approaches in order to increase the economic value of the non-toxic *Jatropha* crop, while maintaining the natural fertility and biodiversity of soils.

2. The *Jatropha* Farm Model

We propose a circular economy approach for the non-toxic *Jatropha* crop in order to increase the economic value of the seeds, reuse their residues, conserve the natural fertility of the soils and reduce the ecological impact of the crop. The proposed model is shown in Figure 1.

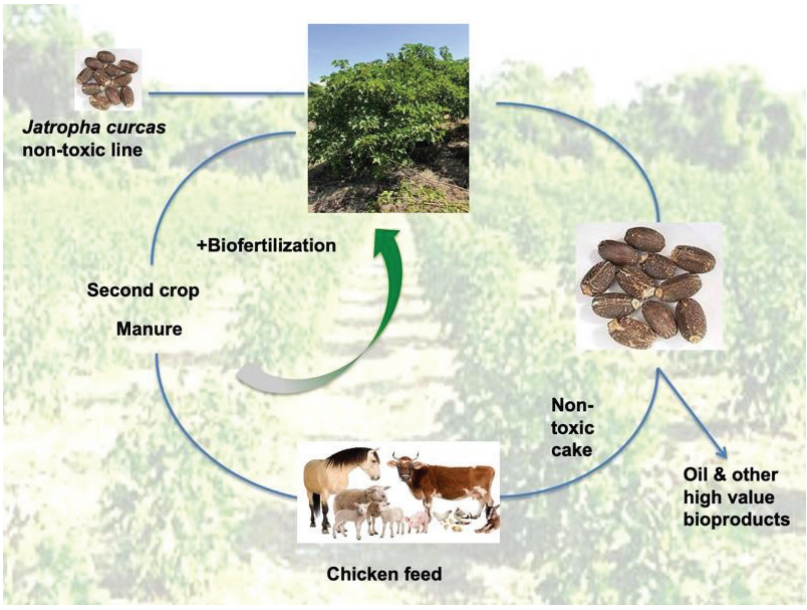

Figure 1. Circular economy proposal of the *Jatropha* Farm.

The non-toxic *Jatropha* variety was used to establish the parcels. The plants are biofertilized with bacteria and mycorrhizal fungi to increase yield, nutrient solubility and organic matter. Upon harvest, the seeds are transported and used for oil extraction. The oil is useful to convert into biodiesel, but also other bioproducts of high value, such as medicines, cosmetics, paints and specialty oils. The residual cake is used to formulate feed for farm animals, such as pigs, cattle or chickens. Their excreta are returned to the *Jatropha* plantation to maintain fertility levels. A secondary crop is established in the plantation for maximal use of land surface and additional economic benefits. The remains of secondary crop plants stay in the field to convert into compost for the next season, increasing nutrients and organic matter. The first part of the proposal consists of the *Jatropha* field experiment; the second part consists of the chicken farm.

3. Preliminary Results

The first part of the *Jatropha* Farm model was established in Xochitepec, Morelos, Mexico, in a plot property of the KSH Innovación Automotriz, a company with which we have a collaboration agreement. The exact location is 18°43′31.3″ N, 99°14′46.6″ W (Figure 2).

Figure 2. Satellite photograph of the *Jatropha* Farm model plot (at left). Xochitepec, Morelos, Mexico. Source: Google Maps.

The parcel covers about 1 ha with 800 plants, in 40 rows of 20 plants each, direction North–South. The non-toxic *Jatropha* plants are 5 years old, healthy, of about 2.5 m height. In the West limit of the parcel, the soil changes visibly to being sandier and the plants are smaller, possibly due to reduced nutrients (Figure 3a). The plots contain 10 plants each. In this part of the field, five treatments with two random-generated repetitions were applied (10 plots). The treatments were as follows:

(**a**) (**b**)

Figure 3. (**a**) *Jatropha* plant in the model parcel; (**b**) Application of biofertilizers and manure.

- T1: Control—untreated plots;
- T2: Biofertilized plots. Five grams of Biofabrica Siglo XXI (Cuautla, Morelos, Mexico) combo product, containing *Azospirillum brasilense* and *Rhizophagus irregularis*, were applied at a 0.5 m distance from each plant stem (Figure 3b). Chicken manure was also applied (100 g per plant). The cost of this treatment was USD 0.34 per plant (USD 3.40 per plot);
- T3: Secondary crop. Common bean (*Phaseolus vulgaris*), variety Negro Queretaro, was sown in 2 rows between *Jatropha* plants, 2 plants per hole, 20 plants per row, 80 plants per plot. The seeds were inoculated with specific nitrogen-fixing rhizobial symbiont,

Rhizobium phaseoli CIAT652 strain, prepared in the laboratory (Figure 4a; emerged bean plants, Figure 4b). The cost of this treatment was USD 0.02 per bean plant (USD 1.6 per plot);

- T4: Biofertilized plots plus secondary crop. The combined assay of the two previous treatments. The cost was USD 0.34 per *Jatropha* plant plus USD 0.02 per bean plant. The cost by plot was USD 5.0;
- T5: Fertilized plants. Chemical fertilizer was bought (formula 18-46-00) and applied at the lower recommended rate of 50 Kg N/ha. The doses were applied as halves, one month apart from each other. The cost per *Jatropha* plant was USD 0.145 (USD 1.45 per plot).

(**a**) (**b**)

Figure 4. (**a**) Preparation of common bean seed inoculant; (**b**) emerged bean plants.

4. Conclusions

The second part of the proposal (the chicken farm) will be performed with the cake from seeds harvested in this season. Thus, the five proposed biotechnological approaches of the *Jatropha* Farm will be complete: the use of a non-toxic *Jatropha* line, the application of biofertilizers, establishing secondary crops, recycling the seed cake, and the reuse of chicken manure. At the end of the season (approximately next October), the economic study will consider the costs and benefits of these strategies. The effect on the soil will be studied, assessing bacterial populations and the content of organic matter. The ecological effect of the mentioned strategies will be studied through carbon and water footprints. The entire experiment will run for two additional seasons, finishing in 2023. Meanwhile, the proposal and the preliminary results will be divulgated in specialized fora, and also in workshops with the general public and the farmers of the Morelos state, who own non-toxic *Jatropha* parcels. Additionally, we are exploring the conversion of *Jatropha* oil into high value bioproducts, such as dermatological creams and dielectric oils. We are in the process of obtaining the genome sequence of the non-toxic *Jatropha curcas* line; it will allow finding differences in comparison with the genomes of toxic *Jatropha* varieties.

The fundamentals of the project allow for it to be extended to other places and crops. We are collaborating with *Jatropha* researchers in Ecuador, who are interested in the applications of the model, and also with oil palm producers in Colombia. Additionally, we will research the possible rebound effects on promoting this crop instead of others that are traditionally produced, acknowledging a life cycle approach and a decarbonization scenario relying on electric vehicles in medium to long term, such that claims on the circular economy can be made from a resource perspective.

Author Contributions: Conceptualization, H.P.; methodology, H.P., D.I.A.-O. and J.C.G.-F.; formal analysis, H.P., D.I.A.-O. and J.C.G.-F.; writing—original draft preparation, H.P.; writing—review and editing, H.P., D.I.A.-O. and J.C.G.-F.; visualization, H.P.; funding acquisition, H.P., D.I.A.-O. and J.C.G.-F. All authors have read and agreed to the published version of the manuscript.

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Proceeding Paper

Innovative Financing Strategies for Climate Action and Sustainable Development †

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Abstract: Despite the importance of infrastructure for climate action and sustainable development, national governments face challenges in accessing financing for the infrastructure they need. To support governments to attract finance to achieve the Paris Agreement and the Sustainable Development Goals (SDGs), we propose a novel approach using the Sustainable Infrastructure Financing Tool (SIFT). Underpinned by a growing global database of 100+ infrastructure funds, SIFT supports governments by providing an evidence-based approach to identifying and prioritizing potential sources of financing for sustainable infrastructure. We demonstrate the potential of SIFT using a national case study for the Caribbean Island of Saint Lucia.

Keywords: infrastructure; finance; climate; SDGs

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1. Introduction

Infrastructure is the backbone of every society; it provides essential services, including energy, water, and transportation to meet the needs of growing populations. Infrastructure also is central to a country's development, and research reveals that infrastructure can influence the achievement of up to 92% of the Sustainable Development Goals (SDG) targets [1]. However, infrastructure can also have damaging impacts on society, not least in the case of climate change. Infrastructure, primarily through transport and buildings in cities, contributes to 75% of all global greenhouse gas emissions that are driving climate change [2] and increases the magnitude and frequency of climate-related hazard events. Infrastructure is particularly susceptible to such hazards. When infrastructure is not resilient, it can disrupt the delivery of critical services and set back development gains that have been established over decades.

As the world deals with the impacts of climate change, infrastructure is a vital enabler of climate mitigation and adaptation for achieving the Paris Agreement. Climate mitigation is promoted by using low carbon technologies in infrastructure development and demand reduction. Similarly, ensuring that infrastructure is resilient to hazards, including green infrastructure for hazard protection, contributes to climate adaptation. With several countries signing the Paris Agreement, sustainable finance is a critical enabler to keep them on track to meet their Nationally Determined Contribution (NDC) targets.

In recent years, the emergence of climate and SDG-related finance from public and private investors such as the Green Climate Fund (GCF) and increased Official Development Assistance allocations to climate change and related sectors indicate a global recognition of the need for increased climate finance [3]. Governments, however, face challenges in attracting this finance to meet their national objectives. Capacity constraints exist in developing bankable projects, identifying financiers, and meeting their financing criteria [4].

Several tools and methodologies have been developed to support governments in overcoming financing barriers. Some of these tools aid the development of bankable projects through the provision of guidance resources for project preparation (Source [5], Project Navigator [6], and Sustainable Infrastructure Tool Navigator [7]). These are relevant for governments with the technical know-how and financial ability to carry out the recommended feasibility studies for project preparation. Other tools focus on mapping out development financiers through retrospective financial reporting on aid allocation (Financial Tracking Service [8], ODF for Infrastructure [9]) and identifying financing opportunities through specific tenders and calls for proposals (Devex [10]).

Existing tools have centered on the major global financiers and their investments in development projects without adequately elucidating how to access the available infrastructure financing or considering the diversity of different country contexts. Several tools also do not reference climate change impacts or progress towards the Paris Agreement beyond the inclusion of environmental and social impact assessments (ESIAs). In an attempt to fill this gap, the United Nations Office for Project Services, in collaboration with the University of Oxford, has developed the Sustainable Infrastructure Financing Tool (SIFT) to provide an intuitive and structured approach to identifying potential sources of financing for sustainable infrastructure. SIFT enables the development of an evidence-based strategy for financing national infrastructure pipelines and climate mitigation and adaptation plans.

The following sections outline the SIFT methodology and demonstrate its application to Saint Lucia, a small island developing nation with unique development challenges. First, the SIFT methodology is explained, including its underlying frameworks and datasets. This is then followed by the practical application in Saint Lucia and the study results. Conclusions are provided in the final section, highlighting the implications of the Saint Lucia study and the relevance of SIFT globally.

2. SIFT Methodology

The SIFT methodological framework (Figure 1) supports the systematic development of a National Infrastructure Financing Strategy (NIFS). Central to this framework is the SIFT process, which is underpinned by a large range of datasets within the SIFT database. The key components of the SIFT framework are described further in the following sub-sections.

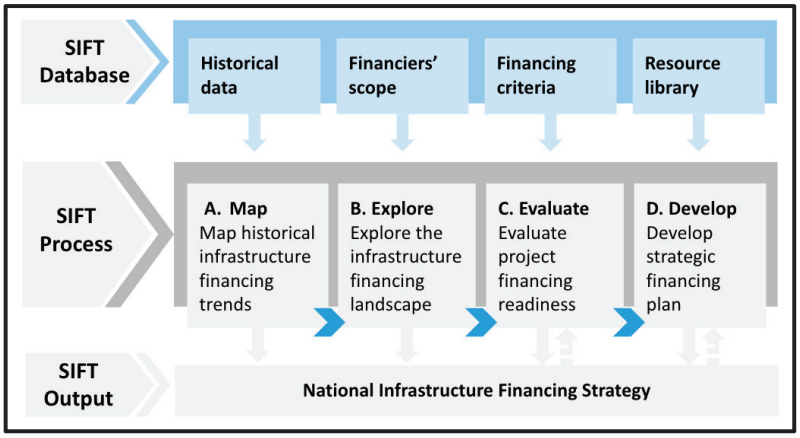

Figure 1. Sustainable Infrastructure Financing Tool (SIFT) methodological framework.

2.1. SIFT Database

Data collection for the SIFT database involved consultation with national governments and a comprehensive desktop review of fund websites and documentation, including annual reports, sustainability reports, financial statements, policies, guidelines, and other relevant documentation. The datasets comprise the following:

- **Historical data:** This captures macroeconomic data on Gross Domestic Product (GDP) and debt levels as well as budgetary data on infrastructure expenditure for the country of focus.
- **Financiers' scope:** This is a growing global dataset of 110 infrastructure funds containing detailed information on their (i) geographic coverage—237 countries; (ii) sectoral coverage—15 infrastructure sectors; (iii) financing mechanisms offered—7 mechanisms, and; (iv) project activities financed—financing available for project implementation, project preparation and enabling activities that build institutional capacity. There is additional data on thematic focus, blended finance options, co-financing requirements, and requirements for private sector involvement. Notably, about 50% of funds currently in SIFT primarily finance infrastructure for climate mitigation and adaptation, such as renewable energy, nature-based solutions, and climate resilience projects.
- **Financing criteria:** This is a collection of 15 financing criteria used by funds to assess projects for financing. Financing criteria are categorized into five general criteria and ten sustainability criteria. The general criteria evaluate the projects' technical and financial viability, while the sustainability criteria assess economic, social, and environmental benefits and alignment with the global agenda. Approximately 90% of funds require that projects demonstrate climate resilience measures and nearly 75% of funds highlight projects' alignment with the Paris Agreement as a priority.
- **Resource library:** This provides a comprehensive set of best-practice resources and actions to guide project preparation and address financing criteria.

2.2. SIFT Process

2.2.1. Step A: Map Historical Infrastructure Financing Trends

SIFT leverages historical country data to contextualize the financing landscape in-country and draw attention to overarching financing needs. Institutional structures and arrangements are also assessed to contextualize the enabling environment and understand the institutional capacity to develop and implement sustainable infrastructure projects. This step provides a foundation for the subsequent analysis and tailors the financing strategy to a country's specific context and needs.

2.2.2. Step B: Explore the Infrastructure Financing Landscape

Data on financiers' scope are analyzed to provide an overview of the infrastructure financing landscape of a country. In addition to mapping infrastructure financiers based on historical data and existing donor relationships, this step enables governments to understand the new potential financing opportunities available for their national infrastructure pipeline.

2.2.3. Step C: Evaluate Project Financing Readiness

An infrastructure project's documentation is evaluated to assess its readiness for financing based on financing criteria used by funds. Through this assessment, the extent to which the project's documentation addresses financing criteria is understood, highlighting areas of strength and improvement to better align with fund requirements.

2.2.4. Step D: Develop Strategic Financing Plan

SIFT identifies well-aligned funds for the government to focus on to finance specific projects in the national infrastructure pipeline. This analysis is based on the exploration of the financing landscape (step B) and the evaluation of a project's financing readiness (step C), considering historical context, over-arching financing needs, and prior funding relationships (step A). The SIFT resource library is then used to inform project-specific strategic actions to address gaps in project financing readiness. An action plan is developed to guide an integrated approach for financing the national infrastructure pipeline. This holistic analysis enables governments to identify and explore opportunities for cross-ministerial collaboration for project preparation, capacity building, and fund engagement.

2.3. SIFT Output

In the form of a succinct report, the NIFS summarizes the findings from each step of the SIFT process and extracts insights to inform governments' strategic decision-making for financing their infrastructure pipelines. Project factsheets that summarize crucial project information and highlight potential NDC and SDG impacts are developed for special focus projects in the NIFS, equipping governments to engage with sustainable infrastructure financiers. By highlighting specific funds that individual focus projects align with, the NIFS enables governments to identify financing opportunities for their infrastructure projects, including those which specifically tackle climate change.

The NIFS highlights opportunities to capitalize on the growing amount of financing for climate mitigation and adaptation to promote climate-resilient infrastructure development. Leveraging the SIFT resource library, the NIFS ensures current and future projects address financing criteria related to climate change. SIFT and the accompanying NIFS enable governments to strategically attract infrastructure financing to achieve their development targets.

3. Application for Saint Lucia

Like most Caribbean countries, certain challenges have limited sustainable development in Saint Lucia, including economic vulnerabilities due to its small size, import dependence, and tourism volatility, which the COVID-19 pandemic has exacerbated. The island is also highly vulnerable to climate hazards, as its geography leaves it especially exposed to the negative impacts of climate change [11]. Its ability to address these challenges has made infrastructure a priority for the Government of Saint Lucia (GoSL), as stated in its Medium-term Development Strategy (MTDS) [12] and the National Infrastructure Assessment (NIA) [13]. The NIA delineates specific national infrastructure-related targets to further progress toward the Paris Agreement and the SDGs, including 35% renewable energy generation, 23% emissions reduction, and a 61% wastewater treatment rate by 2030. However, the MTDS reiterates that inadequate financial resources for infrastructure are barriers to meeting these targets, which are worsened by rising public debt and contraction of the GDP by 20% in 2020 due to COVID-19 [14].

External support from the public and private financiers is key to unlocking the financial barriers to infrastructure development. There is a need for enhanced mechanisms to support GoSL to overcome knowledge gaps regarding the available sources of external financing and the resources required to access these funds. With the responsibility to understand and exploit financing opportunities, decision-makers lack adequate information to take strategic actions to attract funding for infrastructure. Given this, SIFT was applied in Saint Lucia to accelerate financing for the national infrastructure pipeline in alignment with the Paris Agreement and the SDGs and national development priorities. The Saint Lucia NIFS involved extensive stakeholder consultation across government ministries/agencies to facilitate data collection and guide the selection of focus projects across key infrastructure sectors (Figure 2). Consultations with these stakeholders enabled critical evaluation of infrastructure projects at different stages and the intended timelines. Project documentation provided data to assess the projects' readiness for financing. National documents were also reviewed to understand contextual issues and trends to develop practical approaches to access infrastructure finance. This holistic consultative process fostered cross-ministerial coordination to understand needs and capacities regarding infrastructure finance mobilization in Saint Lucia.

Figure 2. Saint Lucia National Infrastructure Financing Strategy—Key Figures.

4. Results and Discussion

4.1. Historical Infrastructure Financing Trends

Following three years of decline in government spending on buildings and infrastructure, expenditure in Saint Lucia grew by 75% to XCD 210 million in the 2019/2020 fiscal year [15]. In recent years, excluding uncategorized spending, transport, health, and disaster reduction have been the most financed sectors [15]. Most infrastructure financing is through bonds; however, loans have increased steadily while grants have declined at a similar rate [16]. This trend is in line with an increasing debt-to-GDP ratio, which reached 87% of GDP in 2020 [14]. Growing debt levels, worsened by the global COVID-19 pandemic, make evident the need to explore alternative infrastructure financing options. Development banks and international organizations have been the largest external infrastructure financiers of GoSL in recent years [15]. Amidst a growing market of private sector infrastructure investors, XCD 351 million of private sector finance has been invested in Saint Lucia through public-private partnerships (PPPs) since 1990, primarily in the energy sector [17]. However, challenges such as small project sizes, constrained local PPP capacity, and hazard vulnerability have limited private investment in the country.

4.2. Saint Lucia's Infrastructure Financing Landscape

SIFT identified 60 funds with the ability to finance infrastructure in Saint Lucia, of which 57% are currently not accessed by the Government of Saint Lucia. Identified funds include development banks, government development agencies, and development finance institutions. These newly identified funds can increase the pool of financiers in Saint Lucia, significantly expanding the potential for infrastructure development. The majority of the identified funds allocate financing to traditional sectors such as energy and transport while emerging sectors like climate infrastructure are gaining prominence.

Loans are the most readily available financing mechanism; however, grants and equity are also available, with 68% and 47% of funds offering them respectively. The availability of blended finance, equity investments, and guarantees draws attention to the opportunity for private sector participation in infrastructure financing through PPPs. Of the available funds, 85% provide financing for project implementation, while 70% finance enabling activities that build institutional capacity and 52% finance project preparation activities.

4.3. National Infrastructure Pipeline Readiness for Financing

Thirty-six projects across energy, housing, water, wastewater, and solid waste sectors in Saint Lucia's infrastructure project pipeline were assessed in the study. The project pipeline included proposal documentation with varying levels of financing readiness (Figure 3). Areas of strength demonstrated by over 85% of projects included alignment with a national strategy and alignment with the SDGs. In contrast, areas for improvement included incorporating climate resilience measures and gender considerations (Figure 4). Given their importance to financiers in Saint Lucia, these areas are critical to address as over 85% of available funds assess these criteria. Aligning projects with the Paris Agreement to meet the country's NDC targets was also an area for improvement; only 31% of projects in the pipeline provided evidence in their documentation to suggest that this criterion is addressed. Gaps in general criteria, such as feasibility studies, impact assessments, and financial viability assessments were also highlighted as areas to strengthen to better attract private sector investment.

The assessment of Saint Lucia's infrastructure pipeline provides a strong rationale for the government to allocate resources to the criteria most required by funds and areas to develop institutional capacity for project preparation. Climate resilience is one of such areas, as it is a criterion used by 85% of funds but incorporated into only 6% of pipeline projects based on the evidence found in proposal documentation (Figure 4). This evaluation was crucial in selecting the focus projects for which specific financing opportunities were identified.

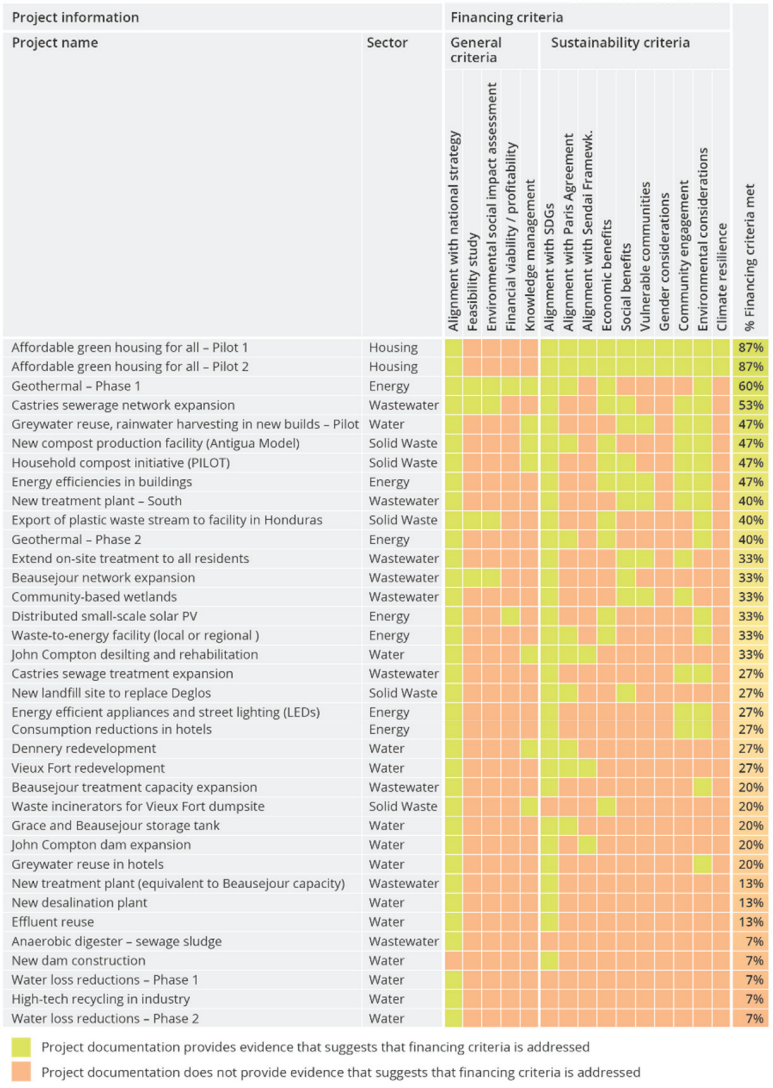

Figure 3. Saint Lucia's national infrastructure pipeline readiness for financing.

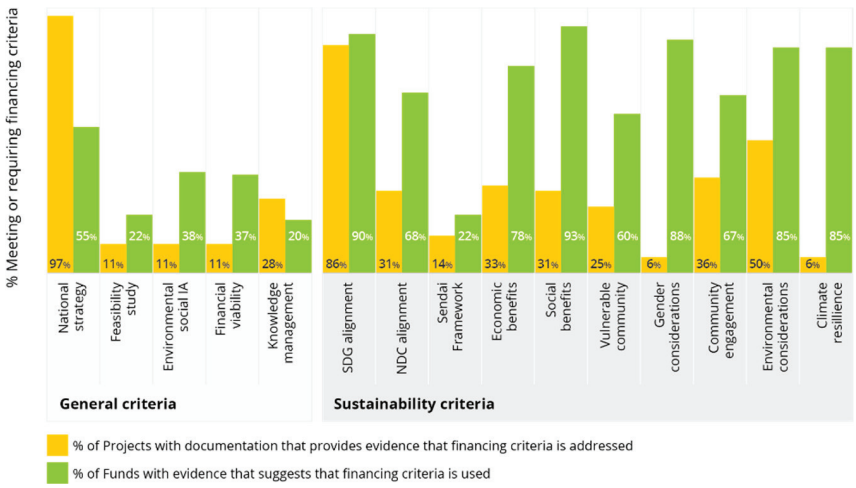

Figure 4. Comparison of financing criteria addressed by projects' proposal documentation versus financing criteria used by funds.

4.4. Strategic Financing Plan

An in-depth analysis was completed for six focus projects across the five sectors to identify, prioritize and exploit specific financing opportunities. The selection of focus projects was based on immediate government priorities, sectoral distribution, projects' financing readiness, and implementation timelines. A project factsheet, fund-alignment assessment, and financing action plan were completed for each project.

For this paper, the project on 'Energy Efficiencies in Buildings' is used as an example of the focus project analysis (Figure 5). At the time of this study, the project's documentation provided evidence that addressed 47% of the financing criteria, including alignment with a national strategy and the SDGs and demonstrating economic, social, and environmental benefits. Five funds were identified as strongly aligned with the project; 80% of these funds offer grants, 40% offer blended finance solutions to attract private sector investment, and 40% finance project preparation activities to further develop the project.

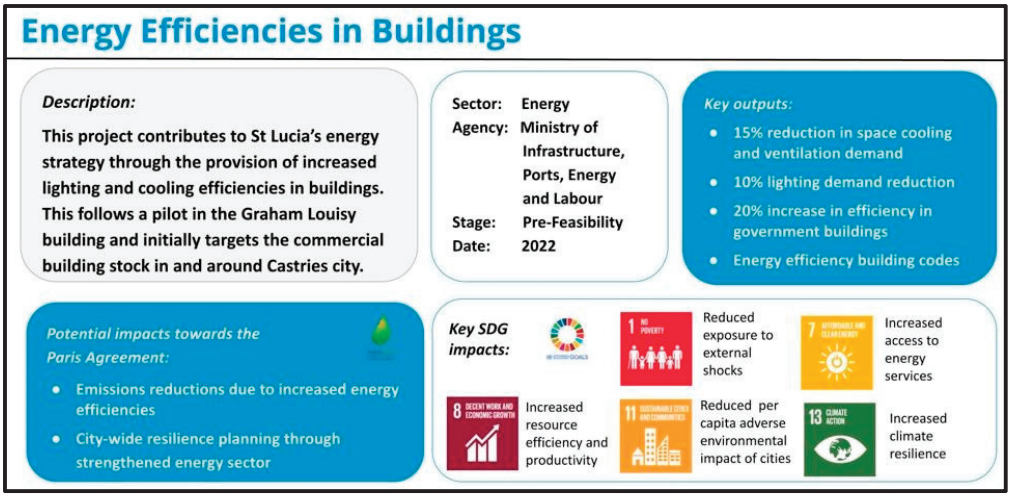

Figure 5. Energy Efficiencies in Buildings Project Factsheet.

Overall, for the six focus projects, 23 of the 60 SIFT funds for Saint Lucia were identified as potential project financiers; GoSL has an established relationship with 14 of these funds. Opportunities for coordination and collaboration between ministries were identified for fund engagement, given that seven funds were highly aligned with multiple projects. To help ensure efficient use of capacity and resources, opportunities to group and package projects with similar timelines and sectors were identified for certain funds.

Of the 15 financing criteria, 11 were identified as areas of improvement for six focus projects (Figure 6). Cross-ministerial collaboration can be leveraged to address gaps in the project documentation of focus projects and build capacity in project preparation to increase financing readiness and better align with funds. For example, all focus projects except one lacked alignment with the Paris Agreement, gender considerations, and climate resilience in their project documentation. A coordinated approach can be taken to identify and exploit available expertise within the government to incorporate these criteria in the focus projects and efficiently build capacity across the respective ministries.

The analysis culminated in a holistic 3-tier action roadmap creating a clear path to secure financing for the focus projects, further developing the national infrastructure pipeline, and ensuring a legacy of evidence-based decision-making for financing long-term infrastructure development.

Criteria	Affordable Green Housing for All	Castries Sewerage Network Expansion	Energy Efficiencies in Buildings	Small Scale Solar PV	Greywater Reuse and Rainwater Harvesting in New Builds	Household Composting Initiative	Number of Projects
Paris Agreement		■	■	■	■	■	5
Gender Considerations		■	■	■	■	■	5
Climate Resilience		■	■	■	■	■	5
Financial Viability		■	■			■	3
Enviro and Social IA	■					■	2
Vulnerable Groups		■				■	2
Feasibility Study	■						1
Knowledge Management			■				1
Sendai Framework						■	1
Economic Benefits					■		1
Social Benefits				■			1

Figure 6. Summary of potential financing criteria development for focus projects.

5. Conclusions

This paper has shed light on the key role infrastructure plays in delivering on the Paris Agreement and the SDGs, and has drawn attention to the need for infrastructure finance mobilization to be rooted in evidence. Using the novel SIFT approach, governments are better able to channel limited resources towards preparing infrastructure projects that address the criteria of financiers and increase the likelihood of attracting much-needed finance, including for projects targeted at climate mitigation and adaptation. The application of SIFT in Saint Lucia produced a financing strategy that provides an integrated approach to infrastructure financing and fund engagement. The NIFS also promotes cross-ministerial coordination and collaboration to strengthen the government's institutional capacity in project preparation and financing. This will yield both short- and long-term benefits and promote efficiency in financing the national infrastructure pipeline. Some limitations of the application in Saint Lucia include the unavailability of project data for some infrastructure sectors, notably transportation, which significantly influences meeting development targets. In addition, the SIFT database is currently under development; hence the financing opportunities highlighted for the country and focus projects are not exhaustive.

In this decade of action, SIFT is an innovative solution with great potential to help governments overcome challenges to infrastructure financing by building strategic partnerships with infrastructure financiers that prioritize positive economic, social and environmental impacts to achieve the Paris Agreement and the SDGs. SIFT is scalable and can be applied to various country contexts, including landlocked developing countries, small island developing states, and least developed countries to promote evidence-based infrastructure financing for climate action and the achievement of sustainable development.

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Proceeding Paper

Transform Suffering by Cultivating Resilience: Embedding SDGs into Intergenerational Digital Health Platform for Navigating the Post-Pandemic Landscape †

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Abstract: The world is being upended by the COVID-19 pandemic which has posed considerable challenges—deaths, fears, unemployment, social distancing, isolation, and lockdowns. Behind the apparent negative impact of an economic downturn, the pandemic has also caused soaring levels of stress and mental health crises, especially in the elderly. Although existing digital health products, services, and platforms are making use of innovative technologies, these alone cannot ensure success, and the scaling up of application of innovative technology for social good requires overcoming numerous bottlenecks. Therefore, it is imperative to identify the integrated needs of stakeholders within the healthcare system and synthesize a holistic approach for sustainable development.

Keywords: Universal Health Coverage (UHC) paradigm; integrated primary care; gerontechnology; age-friendly city; Sustainable Development Goals

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1. Introduction

1.1. Global Challenges, Trends, and Awareness after the Outbreak

The world is facing an unprecedented challenging situation with the COVID-19 pandemic, leading to the global trend of implementing social health practices such as "social distancing". To reduce the transmission of virus, in addition to quarantine and isolation procedures applied to those who have been exposed to or infected with COVID-19, a social distancing policy has also been enforced amongst the general population to reduce the chance of transmission. This may often bring more damage to high-risk groups like the elderly (above the age of 60 years) whose risk of infection is greater as they have a higher rate of morbidity of noncommunicable diseases (NCDs) and more frequent need of hospitalization, intensive care unit admission, and death [1,2]. The elderly population, therefore, is not only experiencing the anxious sense of social isolation and loneliness but also facing the potentially serious mental and physical health consequences. The impact might also be disproportionately amplified in those with pre-existing mental illness, who were often already suffering from loneliness and social isolation prior to the enforcement of public health distancing measures during the pandemic.

An imperative agenda that governmental institutions need to highlight is the aging of the world's population at an unprecedented pace, and these aging populations were posing serious challenges on the health and long-term care systems around the world even before the COVID-19 outbreak. Sustainable and easily accessible elderly care services are in high demand. According to projections from the United Nations, the number of people aged 60 or above will rise from 901 million in 2015 to 2100 million in 2050, increasing from 12% to 22% of the total world population [2–4]. In this population, NCDs are the leading causes of death and disability, and the regional and the global NCD deaths are projected to increase by 15% between 2010 and 2020 to 44 million deaths, with the highest numbers predicted

in the Western Pacific (12.3 million deaths) and the Southeast Asia (10.4 million deaths) regions. Of particular concern is the high level of premature mortality from NCDs [4,5]. At the same time, the significance of future population aging and the increasing prominence of the risk of NCDs are now well recognized by different countries and the corresponding administrations. The statistics also demonstrate how healthcare systems and services, as well as the support of Universal Health Coverage (UHC), must adapt as the global health care burden is shifting toward noncommunicable diseases. Research has also shown that both loneliness and social isolation are associated with an increased risk of NCDs such as heart disease, stroke, cancer, diabetes, and chronic respiratory diseases, especially during the post-pandemic era [1].

1.2. Population Aging in China and Response to Elderly Primary Care Amid COVID-19

Over the past two decades, population aging due to a lower fertility rate and longer life expectancy became more and more pronounced in China. The China National Committee on Aging (CNCA) reported that the number of Chinese citizens aged 60 or above reached 241 million at the end of 2017, representing 17.3% of the country's total population. People aged 65 years or older are expected to make up around 30% of China's population in the next 30 years, and the demographic transition from 1950 to 2050 illustrates that the Chinese population is aging dramatically [6,7]. However, according the global AgeWatch index, China ranks only 90th in psychological wellbeing and 85th in social connections [7–9], which are quite low compared with other countries with similar overall rankings, illustrating the deficits in mental health wellbeing experienced by the elderly in China. Since the pandemic, the recognition of mental health issues such as loneliness along with depressive symptoms has worsened over time in preference to the public health benefits of social distancing. On the other hand, a systematic review concluded that loneliness and social isolation are significantly associated with mental health issues [10–15]. The mechanism of adverse health impacts from loneliness stem from the physiological stress response, while, for social isolation, mental health issues can be caused by behavioral changes such as adopting an unhealthy lifestyle amid social distancing policy, increased alcohol consumption and smoking to alleviate the loneliness, physical inactivity caused by the shutting down of public facilities, poor dietary choices caused by limited market supply, and worsened adherence to medical prescription [16–20]. The reduction in social networking activities also exacerbates these conditions. Recognizing and developing a better understanding of the appropriate mechanisms helps in designing feasible and impactful interventions for improving social connections for the elderly. Concerning these rising challenges associated with the aging population, the CNCA recently released guidelines [21–24] to raise the awareness among Chinese citizens. An elderly-friendly community movement has emerged, aiming to meet the potential social needs caused by aging, such as the need for more high-quality elderly care centers and more resources deployment for gerontechnology initiatives.

1.3. Changes for Preventing the Detrimental Effect of Loneliness and Social Isolation under COVID-19

Preparing for an aging population is essential to the achievement of an integrated SDG 2030 agenda, with the aging problem spanning across the goals of good health, gender equality, reduced inequalities, and sustainable cities. In addition, the global impact of the COVID-19 pandemic has tremendously affected all sectors of society. The widespread lockdowns and preventive measures have isolated individuals, affected the world economy, and limited access to physical and mental healthcare. To tackle these unprecedented challenges, usage of health information technology has recently become an effective strategy, and a growing population from all walks of life is increasingly harnessing digital health tools to increase their awareness of post-pandemic health and wellbeing. However, the elderly population which has been worst affected by both the pandemic and the social distancing measures has seen the least benefits from these digital solutions [25]. The

age-related digital divide reveals the longstanding inequality in access and skills to make use of these new technologies. Nonetheless, digital health can play a critical role in holistically managing elderly primary care and providing preventive measures during the COVID-19 pandemic. Therefore, the elderly's perception of digital health usage plays a significant role in shaping confidence and subsequent behaviors regarding the elderly's intention to use and, thus, the building up of the cornerstone for healthy aging and equity. In recognition of the relevance between advocacy of information literacy among the elderly and the achievement of Sustainable Development Goals, an increasing number of research institutions, government bodies, and industry players are beginning to engage in research and advocacy for gerontechnology, as well as the promotion of digital literacy related to sustainable goals, national and regional development agendas, and institutional advancement. Digital innovations for the development and enhancement of elderly primary care have become an ongoing research focus to redesign and extend the strategic support to healthcare policies and systems globally.

2. Methods

2.1. Elderly Mental Health Digital Platform Framework Design Embedding the SDG3 Goals

The right to health across one's life course has gained increasing awareness with the promotion of the UN's Sustainable Development Goals (SDG), which aim to ensure healthy lives and promote wellbeing for all ages. SDG3 provides a critical opportunity for the world to realize the elderly's right to health. It is not only essential to address the exclusion and vulnerability of elderly in the implementation of the new agenda, but it is also equally important to identify the transformative, inclusive, and sustainable development outcomes on the benefit of elderly's mental health. In view of the challenges and opportunities arising from the aging population in China, a needs assessment study must be benchmarked with WHO's age-friendly model through both quantitative and qualitative research methods. It is significant to align the regional elderly health service standard of China with the global standard and goal.

Prior to designing the digital platform framework (Figure 1) for elderly mental health wellbeing embedding SDG3, several consultations with stakeholders of aging-related projects were conducted from January to June 2021 to obtain a better view of the situation and significance of aging in China, as well as the feasibility of reaching out to the aging community for conducting scientific research.

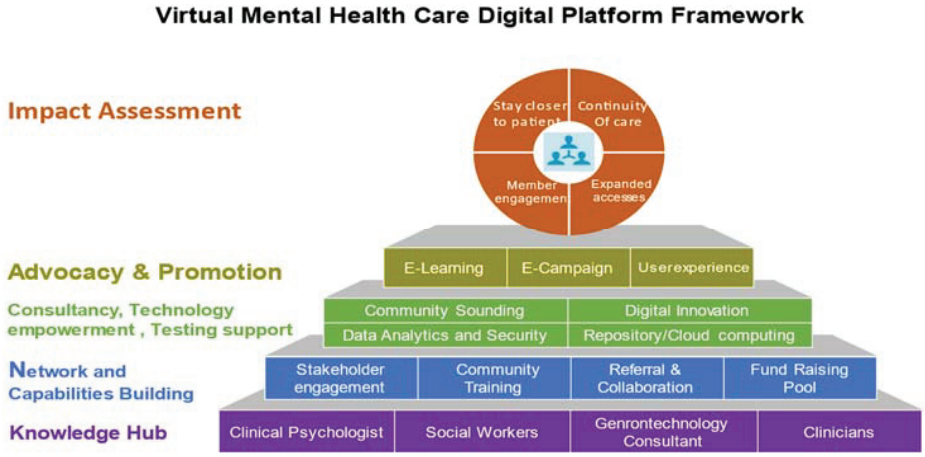

Figure 1. Elderly mental health digital platform framework based on consultation and baseline needs assessment.

2.2. Study Design

Six focus groups were formed, and a total time of 1.5 to 2 h was allocated for each group to participate in interviews with light refreshments offered. Efforts were made

to recruit 8–10 interviewees for each group with similar numbers of males and females. The focus groups were formed on a voluntary basis, and the participating elderly were separated according to two age groups (60–69 and >70 years old). According to the results of the quantitative survey, participants were divided into three socioeconomic statuses (low SES, middle SES, and high SES) on the basis of three dimensions: income, education, and pension types of individual participants. Elderly with a total score from the three dimensions ranging from 0–5 were categorized into the low SES group, while those with a score ranging from 6–10 were categorized into the middle SES group and those with a score ranging from 11–15 were categorized into high SES group (Table 1).

Table 1. Focus group interview constitution: 2 × 3 matrix.

Group	Age	Socio-Economic Status
1	60-69	Low
2	60-69	Middle
3	60-69	High
4	70 and over	Low
5	70 and over	Middle
6	70 and over	High

The procedures and discussion topics for the focus groups were designed with reference to the WHO APC Project Methodology Vancouver Protocol (WHO, 2007). The interviewer led the group participants through the discussion on respective domains of SDG3 and invited them to identify the advantages, stigmas, barriers, challenges, and opportunities to transform the adversity of aging under the effect of pandemic by cultivating resilience to mental health wellbeing, identifying ways to embed SDG3 goals into an intergenerational digital health platform for navigating the post-pandemic landscape, and sharing suggestions for improvement.

Working with the SDG3 framework and agenda on the global aging initiative, the intergenerational digital health platform includes three main functions: (1) screening to detect the level of mental health risk for easy triage, (2) early intervention with appropriate therapy with customized service delivery, and (3) social connection between segmented groups for behavioral changes. These functions are primary intended to address the elderly's baseline needs related to the following:

a. Health (accessible and affordable healthcare services and opportunities without the constraint of time, place, and resources to stay active);
b. Participation (accessible digital tools, information services, social connections, volunteer help, and the need to be valued and respected);
c. Utilization of information technology (recent and ongoing innovations in digital health technologies are achieving great potential and gaining a user base to bring about a transformative impact on mental health diagnosis, preventing, monitoring, and invention).

Grounded in the needs assessment and qualitative feedback from our research, it was identified that the utilization of existing digital health products, services, and platforms that feature innovative technologies are not enough to ensure success on their own. The scaling up of digital technology usage for elderly mental wellbeing requires overcoming multiple challenges. To satisfy the baseline needs summarized above, the engagement of every stakeholder within the healthcare system to transform the traditional disease-oriented and technology-oriented therapies into a people-oriented ecosystem is vital to synthesize a holistic and sustainable approach to establish the paradigm and achieve the goals within the SDG framework. The intergenerational digital health platform was developed to facilitate this transformation, to gain further information on the demand from the society for those innovative practices, and to identify social resources surrounding the mental health enhancement activities. Development of the intergenerational digital health platform went through three stages, as exhibited in Figure 2: stage 1, baseline needs

assessment by on-site visit; stage 2, platform development, demonstration, and collection of elderly's comments and feedback; stage 3, refinement and enhancement of the platform and promotion to the wider aging community.

Figure 2. Three-stage intergenerational digital health platform development.

3. Results

The development and implementation of the intergenerational digital health platform can help strengthen the SDG goals at the regional and global level. Leveraging the power of innovative technology, particularly the implementation of AI and other disruptive technologies, has become essential not only in healthcare companies but also in recent academic research and public deployment of healthcare services. Our research identified the following key factors for future initiatives and more in-depth studies:

a. Overcoming barriers of elderly people's equal right to health: a basket of indicators should be considered holistically before jumping to policy implementation, since the elderly population is subjected to numerous physical, psychosocial, and environmental concerns with their mental health situation.
b. Maintaining social connections with the use of technology-based platform: many of the elderly are neither familiar nor receptive toward new technologies, and the modern style of mobile interaction may not effectively serve their emotional needs without coaching and advocating. The platform developed embedding SDG3 concepts should help older family members and their caregivers with the needed information literacy to overcome such technology barriers.
c. Managing emotions and psychiatric symptoms with minimum stigma: loneliness is often associated with negative cognitions, especially under the pandemic and without deployment of sufficient resources to primary care. In addition, anxiety and depression brought by the social distancing policies during the pandemic may have aggravated social withdrawal issues and exacerbated the feeling of loneliness and isolation.
d. Special care should be taken for elderly people with mental health issues and their family caregivers: In response to the COVID-19 pandemic, the world and the way in which people think and live have changed significantly. In addition to the elderly, caregivers within the family might also be facing high levels of stress and experiencing the feeling of isolation and loneliness. More detailed information on the unique aspects of the effects of the pandemic on elderly mental health should also be considered and highlighted by government agencies, social service organizations, and healthcare providers.

4. Discussion and Conclusions

This study was conducted with the aim of enabling the creation of precision public health services for the public good with the following three objectives: (1) to better deliver and monitor health equity for the elderly via the implementation and scale-up of the intergenerational digital health platform. Our study identified ways to incorporate health-related SDG goals into policy design and accountability measurement in regional mental health services; (2) to ensure that everyone, especially the elderly population, has

equal opportunity to receive integrated care under the Universal Health Coverage (UHC) paradigm. Our study offered decision support indicators valuable for policymakers to exercise judgements on whether their strategies can make a difference; (3) to leverage data science and innovative technology in community care services, enable risk stratification in counseling support, and deliver primary care knowledge to vulnerable groups. Our study explored innovative and sustainable schemes to motivate young people to connect with the elderly by co-creating a primary care data hub for enhanced deployment of digital therapeutics.

Unlike other discipline-specific studies which focused on biomarkers for developing improved diagnosis and therapies, this study made use of community data gathering and analytics to build up the interdisciplinary framework for digital therapeutics, including data from the four dimensions of clinic, home, remote, and community care. This research adopted a mixed data approach for baseline needs assessment and evidence-based knowledge discovery using surveys, focus group interviews, and field trips. Meanwhile, the qualitative data collection took place in the form of structured group interviews through the lens of three digital health start-ups which were working on and delivering intergenerational connection platforms.

With reference to the SDGs, the primary aim of this research was to carry out a needs assessment on elderly mental healthcare and to propose an intergenerational digital health platform design embedding SDG goals. The platform aims to identify service gaps and prioritize needs in elderly care service delivery, in order to cultivate resilience at the regional and global level, as well as promote and strengthen collaboration between stakeholders. In broader sense, the current study strives to prevent the impact of population aging on the long-term sustainable growth by demonstrating a way for the government, community, families, individuals, and industry sectors to join hands and devote efforts to tackling these global challenges.

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Conflicts of Interest: The author declares no conflict of interest.

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The Impact of ESG Performance on the Financial Performance of European Area Companies: An Empirical Examination †

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Abstract: Achieving climate neutrality, as dictated by international agreements such as the Paris Agreement, the United Nations Agenda 2030 and the European Green Deal, requires the conscription of all parts of society. The business world and, in particular, large enterprises have a leading role in this effort. Businesses can contribute to this effort by establishing a reporting and operating framework according to specific Environmental, Social and Governance (ESG) criteria. The interest of companies in the ESG framework has become more intense in the recent years, as they recognize that apart from an improved reputation, ESG criteria can add value to them and help them to become more effective in their functioning. In particular, large European companies are legally obligated by the Non-Financial Reporting Directive (NFRD—Directive 2014/95/EU) to disclose non-financial information on how they deal with social and environmental issues. In the literature, there are discussions on the extent to which a good ESG performance affects a company's profitability, valuation, capital efficiency and risk. The purpose of this paper is to examine empirically whether a relationship between good ESG performance and the good financial condition of companies can be documented. For a sample of the top 50 European companies in terms of ESG performance (STOXX Europe ESG Leaders 50 Index), covering a wide range of sectors, namely Automobiles, Consumer Products, Energy, Financial Services, Manufacturing, etc., we first reviewed their reportings to see which ESG framework they use to monitor their performance. Next, we examined whether there is a pattern of better financial performance compared to other large European corporations. Our results showed that such a connection seems to exist at least for some specific parameters, while for others, such a claim cannot be supported.

Keywords: ESG; STOXX Europe; financial performance; capital structure; profitability; valuation

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1. Introduction

Business leaders have started to realize that in addition to the effective management of their financial capital, it is necessary to adopt measures making them more transparent in terms of internal organization (governance) and more responsible and accountable to society. Moreover, the Non-Financial Reporting Directive (Directive 2014/95/EU) (Directive 2014/95/EU of the European Parliament and of the Council of 22 October 2014 amending Directive 2013/34/EU as regards disclosure of non-financial and diversity information by

certain large undertakings and groups, https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX%3A32014L0095 (accessed date: 30 July 2021)), modified by the Corporate Sustainability Reporting Directive (CSRD) (European Commission, Corporate sustainability reporting, https://ec.europa.eu/info/business-economy-euro/company-reporting-and-auditing/company-reporting/corporate-sustainability-reporting_en (accessed date: 30 July 2021)), puts additional requirements on non-financial data disclosures, according to ESG criteria.

ESG refers to a broad range of Environmental, Social and Corporate Governance factors that might influence a company's ability to generate value. It refers to the incorporation of non-financial elements into business strategy and decision-making in a corporate context. While ESG factors are referred to as non-financial, there are financial implications, as they are linked to corporate competitiveness and profitability (Athens Stock Exchange, 2019, ESG Reporting Guide 2019, https://www.athexgroup.gr/documents/10180/5665122/ENG-ESG+REPORTING+GUIDE/28a9a0e5-f72c-4084-9047-503717f2f3ff (accessed date: 30 July 2021)). According to Bloomberg Intelligence, it is estimated that global ESG assets are expected to reach $53 trillion by 2025, accounting for more than 30% of the $140.5 trillion total assets under management. Given the pandemic and the green recovery across the world, ESG criteria may help in analyzing a new set of financial risks and the harnessing of capital markets (Bloomberg Intelligence February 23, 2021, ESG assets may hit $53 trillion by 2025, a third of global AUM, https://www.bloomberg.com/professional/blog/esg-assets-may-hit-53-trillion-by-2025-a-third-of-global-aum/ (accessed date: 30 July 2021)).

This paper focuses on the relationship between ESG performance and Business Valuation, Business Risk and Capital Structure efficiency. Using financial data of the companies in the STOXX Europe ESG Leaders 50 index, we empirically examined whether the adoption of ESG criteria boosts companies' valuation, reduces their equity risk and makes them more efficient in the way they manage their funds. Our results were compared to respective literature findings.

2. Background

A positive correlation between ESG metric performance and financial performance of organizations has been suggested by many studies [1,2]. This means that ESG disclosures are valuable to investors as they provide them with financially material information.

Verheyden [3] created two different investment universes, one for large and mid-cap stocks in 23 developed and 23 emerging countries ("Global All"), and one for large and mid-cap stocks in 23 developed countries ("Global Developed Markets (DM)"). They then defined six portfolios by using the different ESG criteria for each universe and found that ESG improves risk-adjusted returns.

Giese [4] showed that the risk profile of a company, as a result of lower costs of capital and higher valuations, is affected by ESG performance. ESG information affects Business valuation and performance, both through their systematic risk profile (lower costs of capital and higher valuations) and their idiosyncratic risk profile (higher profitability and lower exposures to tail risk). The research suggests that changes in a company's ESG characteristics may be a useful financial indicator. ESG ratings may also be suitable for integration into policy benchmarks and financial analyses.

Khan, Serafeim and Yoon [5] using a sample of firm-specific performance data on a variety of sustainability investments labelled the sustainability topics as "material" or "immaterial" based on the Sustainability Accounting Standards Board (SASB) Standards. They found that firms with superior performance in terms of material sustainability issues outperform firms with inferior performance in future material sustainability issues. Therefore, ESG disclosures are value-relevant and could potentially be predictive of companies' future financial performance.

De Lucia [6] employed Machine Learning techniques to explore whether a company's ESG practices can lead to improved financial performance in public enterprises. According to one of their key findings, the existence of a positive relationship between ESG practices

and financial indicators can be suggested. This relationship appears more clearly when companies invest in environmental innovation, employee productivity and diversity and equal opportunity policies.

3. Methodology

For our analysis, we used the STOXX Europe ESG Leaders 50 index (https://www.boerse-frankfurt.de/sustainabilities/indices (accessed date: 30 July 2021)). This index includes companies that are global leaders in terms of ESG criteria, based on indicators measured by Sustainalytics (Sustainalytics is a company that provides high-quality, analytical environmental, social and governance (ESG) research, ratings and data to institutional investors and companies), with presence in 17 European countries: Austria, Belgium, Denmark, Finland, France, Germany, Ireland, Italy, Luxembourg, the Netherlands, Norway, Portugal, Spain, Sweden, Switzerland and the United Kingdom.

The EURO STOXX 50 Index is a European leaders' index and provides a blue-chip representation of supersector leaders in the region. The index contains 50 stocks from 8 Eurozone countries: Belgium, Finland, France, Germany, Ireland, Italy, the Netherlands and Spain. Most of the companies of the EURO STOXX 50 Index are also included in the STOXX Europe ESG Leaders 50 index. Thus, to avoid double-counting, we excluded them and kept only the 19 that are solely included in the EURO STOXX 50 Index.

The list of companies in our sample is as follows (Table 1).

Table 1. List of companies in our sample.

#	Name	Supersector2	Country	INDEX
1	ABB	Industrial Goods and Services	CH	STOXX Europe ESG Leaders 50
2	ADIDAS	Consumer Products and Services	DE	STOXX Europe ESG Leaders 50
3	ADYEN	Industrial Goods and Services	NL	EURO STOXX 50
4	AHOLD DELHAIZE	Personal Care, Drug and Grocery Stores	NL	STOXX Europe ESG Leaders 50
5	AIR LIQUIDE	Chemicals	FR	STOXX Europe ESG Leaders 50
6	AIRBUS	Industrial Goods and Services	FR	EURO STOXX 50
7	ALLIANZ	Financial Services	DE	STOXX Europe ESG Leaders 50
8	AMADEUS IT GROUP	Technology	ES	EURO STOXX 50
9	ANHEUSER-BUSCH INBEV	Food, Beverage and Tobacco	BE	EURO STOXX 50
10	ASML HLDG	Technology	NL	STOXX Europe ESG Leaders 50
11	AXA	Financial Services	FR	STOXX Europe ESG Leaders 50
12	BASF	Chemicals	DE	STOXX Europe ESG Leaders 50
13	BAYER	Health Care	DE	EURO STOXX 50
14	BCO SANTANDER	Financial Services	ES	EURO STOXX 50
15	BMW	Automobiles and Parts	DE	EURO STOXX 50
16	BNP PARIBAS	Financial Services	FR	STOXX Europe ESG Leaders 50
17	BP	Energy	GB	STOXX Europe ESG Leaders 50
18	CIE FINANCIERE RICHEMONT	Consumer Products and Services	CH	STOXX Europe ESG Leaders 50
19	CRH	Construction and Materials	IE	EURO STOXX 50
20	DAIMLER	Automobiles and Parts	DE	STOXX Europe ESG Leaders 50
21	DANONE	Food, Beverage and Tobacco	FR	STOXX Europe ESG Leaders 50
22	DEUTSCHE BOERSE	Financial Services	DE	STOXX Europe ESG Leaders 50
23	DEUTSCHE POST	Industrial Goods and Services	DE	STOXX Europe ESG Leaders 50
24	DEUTSCHE TELEKOM	Telecommunications	DE	STOXX Europe ESG Leaders 50
25	DIAGEO	Food, Beverage and Tobacco	GB	STOXX Europe ESG Leaders 50
26	ENEL	Utilities	IT	STOXX Europe ESG Leaders 50
27	ENGIE	Utilities	FR	EURO STOXX 50
28	ENI	Energy	IT	EURO STOXX 50
29	ERICSSON LM B	Telecommunications	SE	STOXX Europe ESG Leaders 50
30	ESSILORLUXOTTICA	Health Care	FR	EURO STOXX 50

Table 1. *Cont.*

#	Name	Supersector2	Country	INDEX
31	FLUTTER ENTERTAINMENT	Travel and Leisure	IE	EURO STOXX 50
32	GIVAUDAN	Chemicals	CH	STOXX Europe ESG Leaders 50
33	GLAXOSMITHKLINE	Health Care	GB	STOXX Europe ESG Leaders 50
34	HSBC	Financial Services	GB	STOXX Europe ESG Leaders 50
35	IBERDROLA	Utilities	ES	STOXX Europe ESG Leaders 50
36	Industria de Diseno Textil SA	Retail	ES	STOXX Europe ESG Leaders 50
37	INFINEON TECHNOLOGIES	Technology	DE	STOXX Europe ESG Leaders 50
38	ING GRP	Financial Services	NL	STOXX Europe ESG Leaders 50
39	INTESA SANPAOLO	Financial Services	IT	STOXX Europe ESG Leaders 50
40	Kering	Retail	FR	STOXX Europe ESG Leaders 50
41	KONE B	Industrial Goods and Services	FI	STOXX Europe ESG Leaders 50
42	LINDE	Chemicals	DE	EURO STOXX 50
43	L'OREAL	Consumer Products and Services	FR	STOXX Europe ESG Leaders 50
44	LVMH MOET HENNESSY	Consumer Products and Services	FR	EURO STOXX 50
45	MUENCHENER RUECK	Financial Services	DE	STOXX Europe ESG Leaders 50
46	NESTLE	Food, Beverage and Tobacco	CH	STOXX Europe ESG Leaders 50
47	NOVARTIS	Health Care	CH	STOXX Europe ESG Leaders 50
48	NOVO NORDISK B	Health Care	DK	STOXX Europe ESG Leaders 50
49	PERNOD RICARD	Food, Beverage and Tobacco	FR	STOXX Europe ESG Leaders 50
50	PHILIPS	Health Care	NL	STOXX Europe ESG Leaders 50
51	Prosus	Technology	NL	EURO STOXX 50
52	RECKITT BENCKISER GRP	Personal Care, Drug and Grocery Stores	GB	STOXX Europe ESG Leaders 50
53	RELX PLC	Media	GB	STOXX Europe ESG Leaders 50
54	ROCHE HLDG P	Health Care	CH	STOXX Europe ESG Leaders 50
55	SAFRAN	Industrial Goods and Services	FR	EURO STOXX 50
56	SANOFI	Health Care	FR	STOXX Europe ESG Leaders 50
57	SAP	Technology	DE	STOXX Europe ESG Leaders 50
58	SCHNEIDER ELECTRIC	Industrial Goods and Services	FR	STOXX Europe ESG Leaders 50
59	SIEMENS	Industrial Goods and Services	DE	STOXX Europe ESG Leaders 50
60	SIKA	Construction and Materials	CH	STOXX Europe ESG Leaders 50
61	TOTALENERGIES	Energy	FR	STOXX Europe ESG Leaders 50
62	UBS GROUP	Financial Services	CH	STOXX Europe ESG Leaders 50
63	UNILEVER PLC	Personal Care, Drug and Grocery Stores	GB	STOXX Europe ESG Leaders 50
64	VINCI	Construction and Materials	FR	EURO STOXX 50
65	VIVENDI	Media	FR	EURO STOXX 50
66	VODAFONE GRP	Telecommunications	GB	STOXX Europe ESG Leaders 50
67	VOLKSWAGEN PREF	Automobiles and Parts	DE	EURO STOXX 50
68	Vonovia SE	Real Estate	DE	STOXX Europe ESG Leaders 50
69	ZURICH INSURANCE GROUP	Financial Services	CH	STOXX Europe ESG Leaders 50

At first notice, by looking at the behaviour of the STOXX Europe ESG Leaders 50 during the last three years, we see that COVID-19 adversely affected this index, as expected. The index price fell by almost 42% in just one month (from +20.67% on 18 February 2020 to −21.89% on 16 March 2020). The fall in the EURO STOXX 50 Index's price, however, was sharper, recording a fall of almost 45% (from +16.08% to −29.09% in the same period). This fact may indicate a greater resilience of the companies in STOXX Europe ESG Leaders 50 in crises if compared to EURO STOXX 50 companies, especially if we take into account the overall behaviour of the index, which seems to recover faster (Figure 1).

Figure 1. STOXX Europe ESG Leaders 50 (blue) and EURO STOXX 50 (orange) development in the last 3 years. Source: Boerse Frankfurt.

Next, using the latest available financial data from Yahoo Finance (https://finance.yahoo.com/ (accessed date: 30 July 2021)) for each company in our sample, we calculated five indicators, namely the Beta, Total Debt/Equity, Profit Margin, Return on Assets and Return on Equity, on average per sector.

These indicators are widely used for the assessment of shareholder's risk, capital structure efficiency, profitability and Asset and Equity efficiency, and we considered them to have provided us with a good overview of the company's performance profile.

Four sectors, namely Personal Care, Drug and Grocery Stores, Real Estate, Retail and Telecommunications, have no representatives in the EURO STOXX 50 Index, whereas the Travel and Leisure sector has no representative in the STOXX Europe ESG Leaders 50 index. For our results to be comparable, therefore, we excluded those sectors from our analysis. We considered this intervention to have not harmed our conclusions, as they concern only 10 firms out of a sample of 69.

Furthermore, for simplification purposes, we grouped Banking, Insurance and Financial Services organizations under the title "Financial Services".

4. Results and Discussion

Certain major firms are required by EU legislation to publish information about how they deal with matters such as social, environmental, corruption/bribery and human rights issues (Directive 2014/95/EU, commonly known as the Non-Financial Reporting Directive (NFRD), establishes the standards for certain large corporations to disclose non-financial and diversity information). This type of information helps investors, civil society organizations, customers, policymakers and other stakeholders in evaluating major firms' non-financial performance and encourages companies to establish a responsible business approach. Currently, non-financial reporting regulations in the EU concern large public-interest firms with more than 500 workers, namely about 11,700 major firms and organizations across the EU, including listed companies, banks, insurance companies and other companies recognized as public-interest institutions by national authorities.

In April 2021, the European Commission adopted a proposal for a Corporate Sustainability Reporting Directive (CSRD), which broadens the scope of the existing reporting obligations under the NFRD to include all major corporations and corporations listed on regulated exchanges. The CSRD imposes more extensive reporting requirements, as well as an obligation to report audited information under EU sustainability reporting standards.

Before analyzing the data and drawing our conclusions, we considered it appropriate to assess whether the ESG reporting frameworks used by the ESG Leaders are compatible with the 17 Sustainable Development Goals (SDGs) of the UN Agenda 2030 or not.

Most corporations use well-established and known ESG monitoring and reporting frameworks, such as the Global Reporting Initiative (GRI) (the Global Reporting Initiative (GRI) is a non-profit worldwide standards group that assists corporations, governments and other organizations in understanding and communicating their impacts on topics such as climate change, human rights and corruption (website: https://www.globalreporting.org/ (accessed date: 30 July 2021)), the Sustainability Accounting Standards Board (SASB) (the SASB is a non-profit organization dedicated to the creation of sustainable accounting standards; investors, lenders, insurers and other financial capital providers are becoming more aware of the influence of environmental, social and governance (ESG) issues on company financial performance, prompting the demand for standardized reporting of ESG data (website: https://www.sasb.org/ (accessed date: 30 July 2021)), the Task Force on Climate-related Financial Disclosures (TCFD) (the Task Force on Climate-related Financial Disclosures (TCFD) was established by the Financial Stability Board to enhance and expand reporting of climate-related financial information (website: https://www.fsb-tcfd.org/ (accessed date: 30 July 2021)) and the World Economic Forum's (WEF) indicators (Figure 2) ('Measuring Stakeholder Capitalism: Towards Common Metrics and Consistent Reporting of Sustainable Value Creation' (available at: http://www3.weforum.org/docs/WEF_IBC_ESG_Metrics_Discussion_Paper.pdf (accessed date: 30 July 2021)), and all of these frameworks are consistent with the 17 SDGs. Six out of the 50 organizations under consideration use internal resources to develop a customized framework for ESG reporting, whereas seven of them monitor their non-financial performance by using the SDGs as a benchmark.

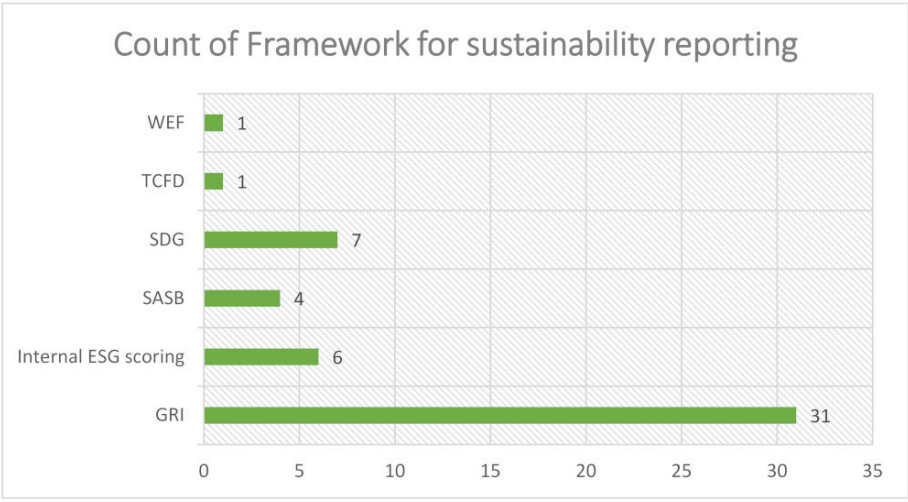

Figure 2. ESG framework used by the ESG Leaders. Source: corporate websites.

In the following, the calculation of the five performance indicators mentioned in the previous section is given (Table 2).

Table 2. Calculation of performance indicators.

	Average of Beta (5Y Monthly)	Average of Total Debt/Equity (mrq)	Average of Profit Margin	Average of Return on Assets (ttm)	Average of Return on Equity (ttm)
Automobiles and Parts					
EURO STOXX 50	1.37	158.74	5%	2%	9%
STOXX Europe ESG Leaders 50	1.64	216.08	5%	2%	13%
Chemicals					
EURO STOXX 50	0.79	33.06	10%	3%	6%
STOXX Europe ESG Leaders 50	0.77	83.50	8%	5%	11%
Construction and Materials					
EURO STOXX 50	0.99	106.28	3%	3%	5%
STOXX Europe ESG Leaders 50	0.64	127.05	10%	7%	26%
Consumer Products and Services					
EURO STOXX 50	0.96	96.71	11%	5%	13%
STOXX Europe ESG Leaders 50	0.89	54.01	9%	5%	11%
Energy					
EURO STOXX 50	1.26	80.82	−11%	0%	−11%
STOXX Europe ESG Leaders 50	1.00	74.29	−5%	−1%	−8%
Financial Services					
EURO STOXX 50	1.75	2.63	−23%	0%	−6%
STOXX Europe ESG Leaders 50	1.28	26.59	14%	1%	8%
Food, Beverage and Tobacco					
EURO STOXX 50	1.40	125.80	9%	1%	4%
STOXX Europe ESG Leaders 50	0.48	110.70	9%	6%	13%
Health Care					
EURO STOXX 50	1.12	79.77	−12%	2%	−18%
STOXX Europe ESG Leaders 50	0.42	58.43	21%	11%	32%
Industrial Goods and Services					
EURO STOXX 50	1.44	102.09	3%	3%	7%
STOXX Europe ESG Leaders 50	0.91	70.89	11%	5%	18%
Media					
EURO STOXX 50	0.68	46.81	9%	3%	10%
STOXX Europe ESG Leaders 50	0.51	339.17	17%	8%	56%
Technology					
EURO STOXX 50	1.52	90.12	47%	−3%	−1%
STOXX Europe ESG Leaders 50	1.14	50.30	17%	7%	19%
Utilities					
EURO STOXX 50	1.25	113.10	−3%	2%	−2%
STOXX Europe ESG Leaders 50	0.64	104.44	7%	3%	8%

The Beta indicator expresses the volatility, hence the risk, of a stock in the market. A stock with a beta greater than 1.0 shows that the stock has a greater fluctuation than the market over time, while a stock with a beta less than 1.0 means that the volatility of the stock is less than the market. Stocks with high-betas tend to have a larger potential return, but are considered to be riskier; low-beta stocks, on the other hand, are less risky but have lower returns. From our analysis, we noticed that, in general, companies with a good ESG performance tend to have lower beta and, therefore, lower risk (Figure 3). However, this was not found to be the case for companies in the automotive sector.

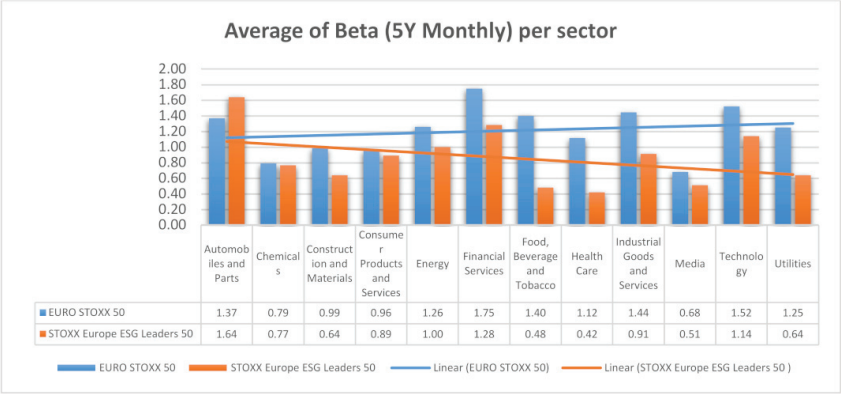

Figure 3. Average of beta (5Y Monthly) per sector.

The debt-to-equity (D/E) ratio is a gearing ratio and is calculated by dividing a company's total liabilities by its shareholder equity. It is used to assess financial leverage and comprises a very useful statistic in corporate finance, as it measures how much of a company's activities rely upon external debt, and expresses the ability of shareholder equity to fulfil all existing obligations in the case of a business downturn. Although the comparison of the D/E ratio across different industrial sectors is sometimes problematic, since optimal levels of debt differ across the various sectors, in general, higher leverage ratios often imply that a firm or stock carries a greater risk for the shareholders.

Our analysis showed that the D/E ratio is at similar levels, regardless of whether companies have good ESG performance (Figure 4) within the same sector, except for Media companies, where the ESG demonstrated more leverage than the rest. This result agrees with [7], who suggested that when it comes to a company's ability to raise cash or its capital structure, ESG performance is not critical. According to them, there is still a long way before sustainability is regarded as an important and well-integrated component in investment decisions. They at least did not see an obvious association between ESG performance and fund-raising ability, leading to the conclusion that sustainability measures have no impact on the optimal capital structure. However, they found that sustainability ratings can be used by a corporation to change its optimal debt levels, run more efficiently with cheaper capital, and assist managers in maximizing firm value. Having a better knowledge of how the ESG rating influences the capital structure could aid a business in its decision-making processes as regards the funding of its organization. This knowledge would enable management to better understand how the investments required to obtain the ESG grade affect the firm's value as well as the financing dynamics [7].

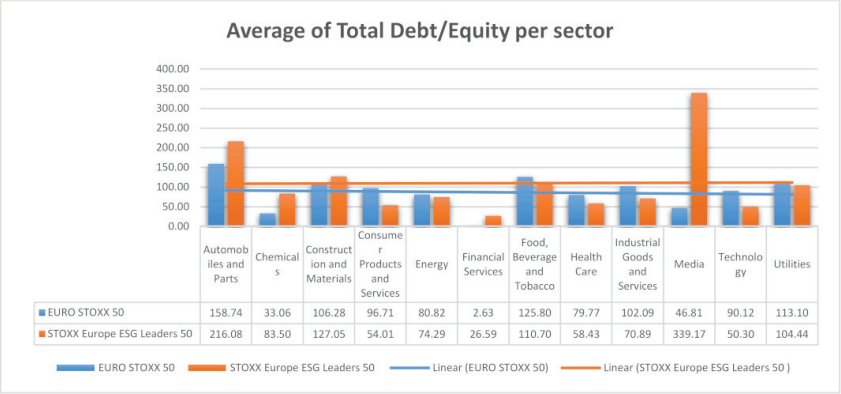

Figure 4. Average of total debt/equity per sector.

Return on assets (ROA) measures a company's profitability to its total assets. ROA provides information about how effective a company's management is in generating earnings from its assets. It is expressed as a percentage and, in general, the greater the ROA, the better. From our analysis, it was found that there is a clear superiority in the profitability of companies that have good ESG performance in all sectors (Figure 5). This result agrees with the finding of [8], where a positive impact of ESG performance on ROA is suggested.

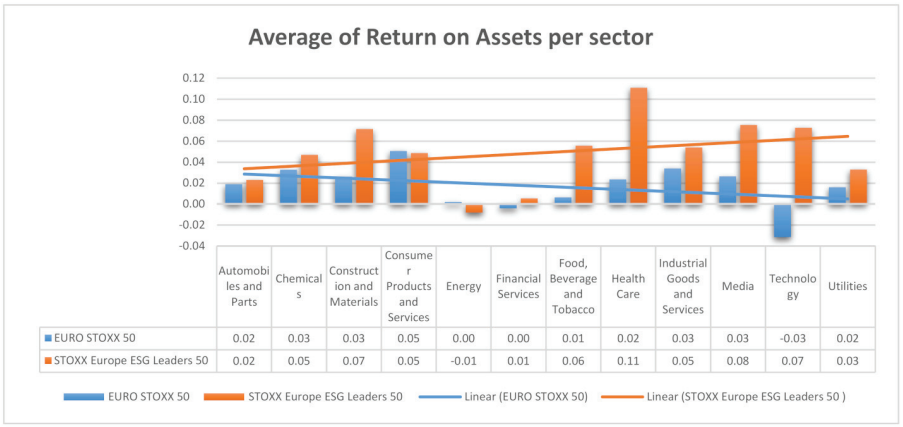

Figure 5. The average return on assets per sector.

Return on equity (ROE), similarly to ROA, is a financial performance metric that is derived by dividing net income by shareholders' equity. ROE is defined as the return on net assets since shareholders' equity equals a company's assets minus its debt. Therefore, the ROE is a measure of a company's profitability to its stockholders' equity.

Our analysis showed, as with ROA, that companies with good ESG performance have a better return on equity than the others (Figure 6). Even in the sectors with negative returns, such as the energy sector, ESG leaders demonstrate less negative return on equity than the others. Our findings on the relationship between both ROA and ROE are in line with the work of De Lucia [6], which concludes, using machine learning techniques, that a firm's financial performance improves as a result of good ESG.

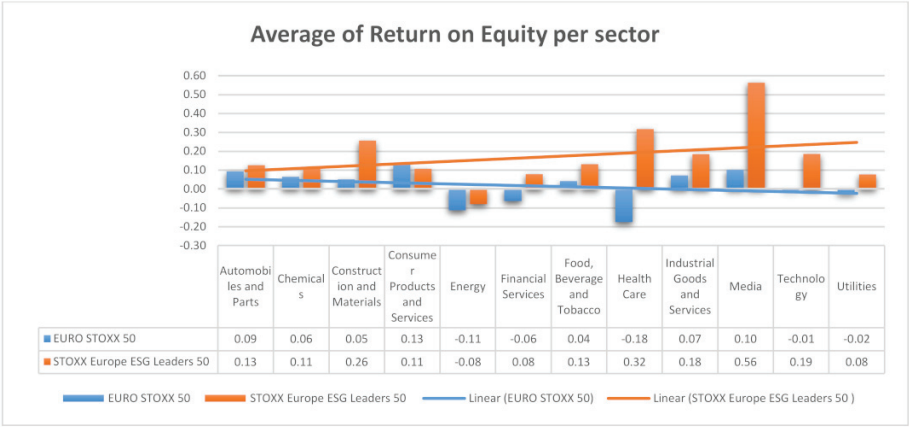

Figure 6. The average return on equity per sector.

Profit margins are one of the most basic and commonly utilized financial metrics in the business world. A company's profitability is usually measured at three levels—gross profit, operating profit and net profit. The simplest indicator of profitability is gross profit, which is calculated as the difference between sales revenue and the cost of sales, and the profit margin is derived by dividing this difference by the revenue.

Our examination does not show a clear relationship between profit margin and ESG performance. In some sectors, ESG leaders seem to have a higher profit margin, while in others, the opposite is true (Figure 7). This may be due to the specific characteristics of either the sector or the business and the way it operates to be profitable. Further, both factors that determine a company's profit margin, namely asset turnover and sales costs, are influenced by several factors, such as area of activity, competition, international financial conditions and other parameters that seem to not be directly affected, neither positively nor negatively, by ESG performance.

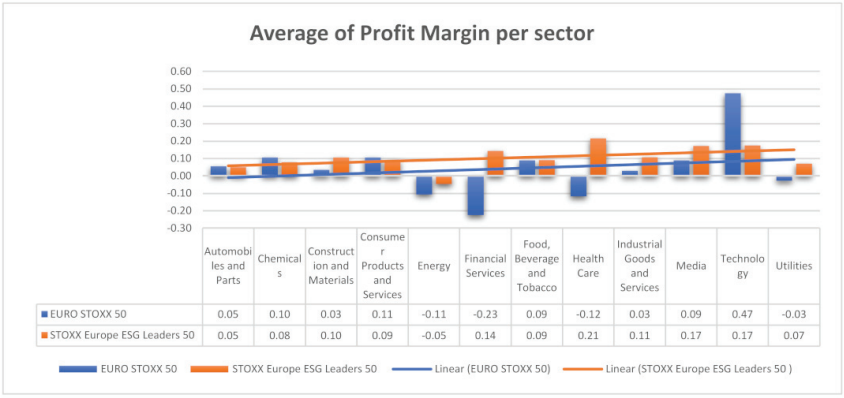

Figure 7. Average profit margin per sector.

5. Conclusions

We examined the connection between good ESG performance and sound financial results. Our sample of companies covers a wide range of industry sectors, and assuming that the tone is given from the top, we believe that our conclusions are representative of all sectors.

Business operations that comply with the established ESG principles are beneficial not only for society and the environment but also for the business itself in a variety of ways. We found that 44 companies out of the 50 included in the STOXX Europe ESG Leaders 50 index already use well-known ESG reporting frameworks that are compliant with the 17 UN SDGs. The remaining six devote resources to the development of internal systems to monitor their performance according to ESG criteria.

As far as the results on the correlation between ESG performance and financial results are concerned, our study showed that the beta coefficient, a very widely used measure for shareholders' risk, tends to be lower in companies with strong ESG performance, thus implying a comparatively lower equity risk; firms in the automotive sector are an exception, however.

Concerning the D/E ratio, our study revealed that, except for media firms whose ESG leaders demonstrate a relatively better D/E, it does not seem to be explicitly affected by ESG performance. This result is in line with studies that suggest that ESG performance is not a critical factor for a company's capital structure efficiency or its ability to raise funds. Further, our study showed that in some sectors, firms with strong ESG performance, in general, demonstrate a greater profit margin, but this was not found to be the case for all sectors.

Last, our analysis revealed a clear dominance in the profitability of companies that have good ESG performance compared to the rest, in all sectors. This was observed to be the case for both ROA and ROE and agrees also with results from the literature.

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Renewable Energy for Smallholder Irrigation: A Technology Adoption Toolkit †

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Abstract: Smallholders are the backbone of livelihoods in the Global South. Yet, many remain water- and energy-insecure. For this challenge, this study presents a toolkit to stimulate the sustained adoption of renewable energy-powered water pumps for smallholder irrigation. A human-centered design method was used to co-create it. It first consisted of a prototype that was tested by experts. Their feedback was crucial to further improving the toolkit, thereby making it a more robust instrument. The design posed limitations worth considering in future research. Additionally, the spread of water pumps implies environmental and economic concerns. To enhance its benefits, the toolkit still requires thorough testing in diverse contexts.

Keywords: renewable energy; water pump; irrigation; smallholder farming; technology adoption; toolkit; co-creation

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1. Introduction

Smallholder farming is the backbone of livelihoods in the Global South. It largely sustains local economies in low- and middle-income countries. It produces roughly 80% of the food in sub-Saharan Africa and Asia, though barely accounting for 12% of the global farmland [1]. Successful smallholder farming is therefore a main pillar required for the eradication of poverty and hunger, and thus in the accomplishment of SDG 1 and SDG 2. Yet, many smallholders worldwide remain energy- and water-insecure, which is a major barrier in this endeavor [1,2].

Although conventional diesel-powered pumps are generally available in low-resource settings, their use poses economic and environmental downsides [3]. These pumps require the constant input of cost-intensive fuels, which in turn are a constant source of pollution. Renewable energy-powered pumps (RE-pumps), on the flipside, are environmentally sound, technically simpler, and more affordable alternatives. They harness clean energy (i.e., hydro, solar, wind) to drive pressurized irrigation systems, and hence, contribute to sustainably intensifying food production [4,5]. Moreover, given that RE-pumps neither depend on the availability of (inaccessible) fossil fuels, nor grid electricity, they are good candidates to support irrigated farming in rural communities.

RE-pumps are potential key technologies to leverage local-level synergies of the water–energy–food nexus. Despite the efforts to implement these technologies in smallholder settings, their uptake remains a challenge [6]. The effective adoption of RE-pumps is a

complex process that depends on a number of (non-)technical factors. These pertain to the technology (e.g., cost, ease of use, trialability, complexity), the adopter (e.g., education, purchasing power, risk aversion, environmental orientation, innovation awareness), as well as the broader context (e.g., type of farm, market development, legal regulations, financial support and subsidies, institutional environment). This entangled interaction renders the decision to adopt (or not adopt) an RE-pump oftentimes to be an unclear, difficult and unstandardized process [7].

In this respect, some researchers [8–12] have focused on adoption frameworks. Others [7,13–15] have mapped the process of adoption of RE-pumps in smallholder farming. In addition, there are a (limited) number of tools [16–18] that aim to increase their adoption rates. These tools, however, do not focus on stimulating the thinking process prior to the adoption but rather create awareness and supply information to the end users. To the best of our knowledge, there are no studies on participatory tools to facilitate the decision-making of technological adoption in smallholder settings.

The objective of this paper is thus to introduce and discuss a co-designed toolkit focused on the sustained adoption of RE-pumps for smallholder farming. This toolkit provides a space for discussion between involved stakeholders (i.e., farmers, government(s), NGOs, technology manufacturers, and providers). It will help them in understanding key variables and tipping points for the applicability of RE-pumps, as well as in exploring possible business models to enable this process. To achieve that goal, first, the key adoption variables are identified from the literature. Second, a conceptual adoption framework is defined based on clusters of those variables. Third, a minimum viable product (MVP)—a first version of the toolkit consisting of a collection of tools and canvases—will be developed upon the framework. Fourth, from this first version, cyclic iterations will be carried out to arrive at a refined, co-created product.

2. Literature Review and Cases Studies

Key variables influencing the adoption of RE-pumps were identified and clustered through a literature review. Nine case studies, covering technology, socioeconomic, and business models aspects, were used for this purpose. This step was relevant to developing a sound conceptual framework for the development of the toolkit.

2.1. Cases on Technical Aspects

These aspects pertain to the biophysical characteristics of a given context, which will determine whether an RET will fulfill its expected goal. People cannot influence them or can influence them to a limited extent. These, unique to each geographic location, condition the technical performance of an RE-pump.

The first case [19] focused on the adoption of solar irrigation technologies in the Indian province of Utter Pradesh. A survey among 1600 farmers showed adoption concerns about climate variations, water availability, and certain farm characteristics such as soil composition and the slope of the land. The second case [20] assessed the adoption of a hybrid wind–solar water pumping system in Egypt. It focused on *weather conditions* and the *climate* of the different seasons. In this case, wind and solar energy complemented each other. The third case [21] focused on food security and multiple cropping seasons in Ethiopia. Relevant variables obtained from this case were *water demand*, *growing seasons*, and *crop type*.

2.2. Cases on Socioeconomic Aspects

The adoption of RE-pumps is also related to variables that go beyond the technical sphere. Socioeconomic aspects are key to addressing the limitations and opportunities of smallholder irrigation. Here, both the institutional and broader context, as well as the individual and household levels were considered.

The fourth case [22] studied smallholders' perceptions of RE production in West Bengal, India. It concluded that farmers assess RETs based on their *holistic experiences*

and *background*, reinforcing the importance of integrating the technical aspects (e.g., local climatic conditions and soil fertility), with external variables, such as *fluctuations in market prices* for agricultural inputs and outputs. Moreover, it suggested that 'early adopters' are usually higher socioeconomic actors with more access to resources (e.g., water, land, financial capital), which allows them to take the *risks* typically associated with RETs.

The fifth case [23] examined farmers' choices of water pumps in Pakistan. It found that *educated, younger,* and *wealthier* smallholders are more prone to adopt RE-pumps. It also indicated that *female* farmers are more likely to use RE sources. On the contrary, it identified that *lack of credit availability* prevents smallholders from adopting them.

The sixth case [14] elaborated a general review of the policy and institutional barriers to RETs adoption in Bangladesh. They considered variables such as the *lack of training programs* and *financial incentives* to encourage private sector investment, the limited *available empirical knowledge* on RETs, and lack of public awareness, among others.

These variables were organized in different clusters of resources, namely physical, human, financial, social, and natural [15,22].

2.3. Cases on Business Model Aspects

Business models and entrepreneurial processes are important as they are a blueprint for business success. These processes determine whether the adoption of a certain technology is economically feasible. By considering the financial investment and return, it can be estimated to what extent the long-term adoption will be impeded or facilitated.

The seventh case [21] assessed the demand and adoption constraints for small-scale irrigation technologies in Ethiopia. It established that variables including a *lack of access to financial advice*, the *purchase price*, or the absence of access to *financing methods* constrain or enhance the technology adoption from an economic perspective.

The eighth case [24] found that, for smallholders in Asia and sub-Saharan Africa, the adoption is oftentimes hindered by insufficient *affordability*, high *purchase prices,* and *technological illiteracy*. Furthermore, in rural areas, there is limited *access to stores* and *technological support*, which creates additional barriers to the adoption of suitable technologies.

The ninth case [13] focused on a predictive adoption framework for smallholder farming in low-income countries. It acknowledged crucial variables, among others, as *additional running costs* (e.g., fuel, replacement parts), *added labor requirements*, *information asymmetry* (such as unfamiliarity of financial benefits), and *time until break-even*.

2.4. Research Gaps

The analyzed cases show gaps such as a lack of geographic diversity and holistic consideration for adoption variables (Table 1). Most cases focused on sub-Saharan Africa or the Indian subcontinent, and a specific domain, such as certain irrigation technology. Moreover, studies tend towards linear approaches that disregard the dynamics of the adoption of RE-pumps in the real-world context. Additionally, long-term adoption is generally not observed and scholars have neglected the broader context of the environment. To avoid those pitfalls, this research has focused on developing a toolkit that holistically and dynamically considers the relevant variables related to long-term adoption.

Table 1. Cases, findings, and research gaps.

Aspect	Ref.	Main Findings	Gaps
Technical	[19]	Adoption factors for solar irrigation technologies	Only considering solar-powered irrigation
	[20]	The value of a hybrid RE pumping system	Only looking at the technical variables
	[21]	Influence of RE-pumps on food security and wealth	Not purely focused on RETs

Table 1. *Cont.*

Aspect	Ref.	Main Findings	Gaps
Socioeconomic	[22]	Socioeconomic status and access to resources are key in determining the adoption rates	Focused on farmers' perceptions, ignoring the political/institutional context
	[23]	Younger, wealthier, and more educated smallholders are more likely to adopt RE-pumps	Only includes a quantitative approach to understanding adoption
	[14]	The local institutional context is crucial for ensuring the long term adoption of RET	Analyzes RET projects from a general perspective
Business model	[21]	Credit constraints are key determinants of adoption and demand for irrigation technologies	Focused on one specific region, cross-sectional, linear approach, focused on credit-constraints
	[24]	The successful adoption poses challenges related to equity, efficiency, and sustainability	Limited temporal horizon
	[13]	Costs, education, and additional requirements are relevant considerations for technology adoption	Limited temporal horizon, linear approach

3. Conceptual Framework

Based on the identified variables and clusters (Table 2), a framework that holistically combines the technical, socioeconomic, and business models aspects has been conceptualized (Figure 1). This framework was used as a compass to guide the development of the adoption toolkit.

Table 2. Clusters of key variables of RE-pump adoption.

Aspects	Clusters	Variables
Technical	Water availability	Groundwater table, aquifers, wells, surface waters, water depletion, water quality
	Climate	Weather conditions, climate change, natural disasters
	Farm characteristics	Soil type, dimensions of the farm, slope, hydraulic head, water storage
	Water demand	Irrigation schedule, crop type, irrigation type
	Durability	Robustness, quality, usability, complexity, maintenance
Socioeconomic	Physical resources	Farm size, land ownership, available infrastructure (e.g., irrigation canals, roads)
	Human resources	Skills, educational level, jobs, and sources of income
	Financial resources	Wages, services, access to loans/credit
	Social resources	Networks, gender roles, social status
	Natural resources	Access to land and water, details of agricultural system (crops, animals, inputs)
Business model	Pre-purchase	Access to physical stores/websites, advisory support, switching-costs
	Purchase	Access to finance, purchase price
	Post-purchase	Input-price, additional labor requirements
	Long-term	Time to break-even, awareness of financial benefits, cost-savings/profitability

The three-level pyramid framework shows the conditions and processes relevant to the long-term adoption of RE-pumps. The foundation (first level) consists of tangible biophysical aspects such as the climate and landscape conditions and intangible socioeconomic aspects such as wealth and education. They engage in a reciprocal interaction whereby biophysical aspects may determine socioeconomic conditions and socioeconomic development can shape the natural environment. Based on that interaction, a suitable business model (second level) must leverage the advantages and harness the limitations of the biophysical and socioeconomic aspects. A suitable business model considers factors such as access to financing methods, advisory support, or profit advantage in order to ensure that it fits the conditions of the context. The irrigation technology (third level) should be selected based on those contextual aspects, and delivered through an appropriate business model. Then the model is solid and facilitates its long-term adoption. Long-term adoption can

influence the base of the pyramid by, for example, increasing wealth, providing jobs, and changing the landscape to adjust to the new agricultural infrastructure and needs. The model then requires an adjusted business model. The adoption process becomes highly dynamic. Additionally, inputs (e.g., outside knowledge, materials, machinery) are required to sustain this process. Broader factors such as global trends (e.g., food prices, trading, and consumption patterns) can influence the whole system.

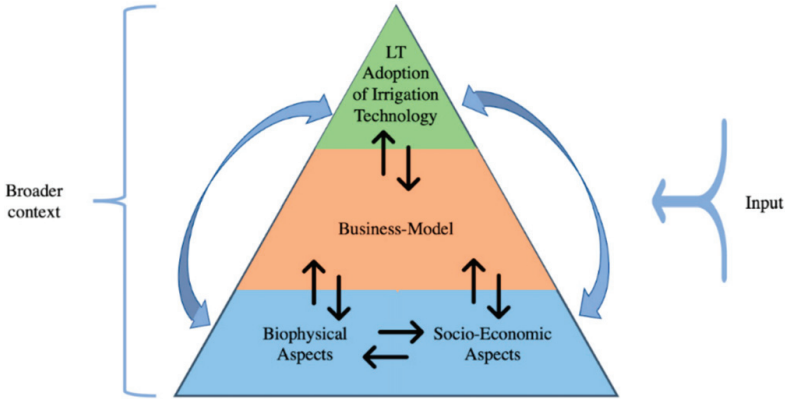

Figure 1. Proposed conceptual framework: interaction of conditions that impact the long-term adoption of irrigation technologies.

4. Methodology

A human-centered design method, consisting of four stages, was used to develop the toolkit (Figure 2). First, based on the classification of relevant adoption variables, a minimum viable product (a version of a product with just enough features to be usable by early customers who can then provide feedback for future product development) (MVP) was designed [25]. Second, an internal iteration to test the MVP was conducted through role-play sessions [26]. Third, an external iteration of the MVP was carried out with stakeholders involved in the topic [27]. Fourth, the toolkit will be deployed in actual on-field cases with smallholders. This last step, which fell out of the temporal scope of the present paper, will provide further insights for the refinement of the toolkit and the later data collection and improvement.

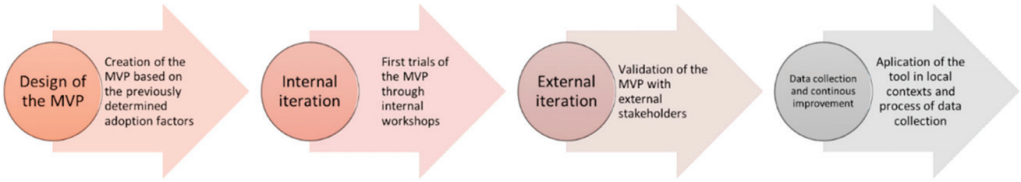

Figure 2. Steps towards the development of the toolkit.

The design method sought to facilitate the co-creation process, by bringing different actors together from the early stages, thereby aiming for a more holistic toolkit.

4.1. Design of the MVP

The MVP consisted of a number of canvases, which were articulated around the key adoption variables and clusters previously identified. These canvases were an early prototype of the envisioned tools, subjected to quick design and trial [25]. As this procedure was partly based on assumptions, the MVP was subsequently tested and improved in controlled environments.

4.2. Internal Iteration

To validate the MVP, a first web-based iteration was conducted through role-playing sessions. This technique is useful to test ideas in complex dynamic systems such as the

adoption of RETs. It rapidly generates new insights and shows the limitations of the proposed designs.

To our goal, independent experts in the fields of irrigation, innovation, energy, and water management were purposively approached. Different roles of decision-makers involved in the adoption of RE-pumps were assigned to these participants. They were instructed to test the ease of use and completeness of the MVP and to highlight as many unaccounted/inconsistent elements as possible. Their feedback was collected through a semi-structured questionnaire. It included a number of open questions that captured the viewpoint of the participant. It also considered multiple-choice questions about the quality of the role-play. The feedback was analyzed and used to refine the MVP.

4.3. External Iteration

Purposely selected stakeholders were presented with an improved version of the toolkit. These actors were actually involved in the implementation of RE-pumps for smallholder farming. Similar to the internal iteration, they were asked to test the ease of use and completeness of the toolkit. Their feedback was collected through semi-structured questionnaires. Through this step, the toolkit was further refined considering the changing preferences, emerging technologies, and varying ranges of stakeholders.

4.4. Deployment and Continuous Improvement

In a final step, yet to be conducted due to the limited scope of the present research, the toolkit will be used in smallholder communities. This step will collect data from the end users to further improve the toolkit.

5. Results

5.1. Design of the MVP

The MVP consisted of three sub-canvases, one main canvas, and a business model booklet. The three sub-canvases sequentially covered socioeconomic, technical, and business model aspects. These ensured the interaction of the identified clusters of key variables. The first one aimed to determine the socioeconomic profile of the participant. The second one sought to pinpoint whether a certain RE-pump is suitable in the given context. The third one, based on the first two, mapped the financial and market conditions.

The main canvas was split into two sections. The first section translated and summarized the contents of the sub-canvases by means of visual scoring systems. It highlights key points of the participant's current situation. The second section engages in a reflection process on what is required to effectively adopt the desired RE-pump, thereby facilitating later decisions. Lastly, the booklet presented different business models that might help bridge the gaps that the user identified and reflected upon in the concluding section. Its goal is to educate and inspire participants on different delivery options available/desirable in the given context. The Supplementary Material of the toolkit can be found in [28].

5.2. Internal Iteration

Four experts tested the MVP and provided their feedback. It focused on the understandability, usefulness, and missing parts of the different canvases. The feedback revealed two main needs: overall clarification in terminology and questioning, and the simplification of any forms of calculations of technical and financial aspects. The second need in particular may involve high susceptibility to errors, thus reducing the confidence of the participant in filling it correctly. Because of this, it was decided to greatly simplify any calculation or to eventually leave it out completely.

5.3. External Iteration

Ten external experts were contacted to conduct these tests. They were selected to cover a diverse range of RE-pumps manufacturers, distributors, NGOs, and academics. Just three of them provided feedback. As for the internal iteration, they were asked for the

understandability, usefulness, and missing parts of the toolkit. Their feedback focused on keeping the tool simple in terms of calculations and length. The main canvas was deemed as particularly unclear. They suggested the addition of more images to increase clarity. As missing points, they identified gender-related factors and the portability of different pumping systems.

5.4. Deployment and Continuous Improvement

As pointed out above, the deployment of the iterated toolkit is out of the scope of the present work. As such, it remains pending to engage in a process of continuous improvement. Nonetheless, the expected result from this last stage is to co-produce, alongside actual smallholders and related actors, a refined toolkit resulting from a participatory process of knowledge sharing. Moreover, the regular use of this holistic toolkit may facilitate the field data collection that ensures its continuous improvement.

6. Discussion and Conclusions

Key adoption variables and their interactions reflect the complexity of RE-pump adoption in smallholder settings. This aligns well with studies highlighting smallholder agricultural innovation as a complex process [12,13]. This multifaceted process requires a comprehensive look at the technology itself, local socioeconomic processes, and their connections with local and national contexts. As a response, the designed toolkit aimed to holistically integrate those relevant adoption variables. For this purpose, the human-centered design approach allowed for the translation of the clusters into an MVP that was piloted later [27]. Through two iterative cycles of testing and feedback, it was possible to engage experts in the co-creation of the toolkit. These actors keenly spotted pitfalls and lack of clarity within the canvases, in consonance with [27]. More importantly, their pooled knowledge enabled the shared improvement of the toolkit, which thereby may capture more accurately the real-world dynamics of RE-pump adoption. At the same time, those iterations showed the toolkit's capacity to be flexibly adapted to different requirements.

The toolkit provides ground to surpass the limitations of traditional top-down, linear, and short-term approaches to technological adoption [12]. It offers a space for stakeholders to identify, reflect, discuss, and negotiate crucial enablers and barriers in the uptake of RE-pumps. On this basis, the toolkit also has the potential to delineate possible roadmaps for the whole adoption process, from the introduction of the RE-pump to its sustained adoption. The application of the toolkit, however, should not be limited to the purchase or use of a water pump with virtually no emissions. It must rather be understood as a means of bridging gaps between smallholder farming and sustainable agricultural mechanization and production. In the long run, this synergy can create a larger positive impact on food security, economic development, responsible production, and overall sustainable development of societies in the Global South.

The design of the toolkit also posed a number of limitations worth considering. Web-based piloting was a useful way to overcome fieldwork limitations related to the ongoing COVID-19 crisis [29]. However, it also prevented the gathering of on-the-ground data from actual smallholders. These actors would have exposed the toolkit to perspectives that the current research has likely overlooked, despite the efforts of the research team. Follow-up proposals for field piloting are therefore crucial to ensure its further improvement. Another limitation is that the testing consisted of merely two iterations and seven experts. More actors, fulfilling diverse roles, must thus be incorporated to ensure more robust completeness of the tool.

The application of the toolkit, and its potential contribution to increasing adoption rates of RE-pumps in smallholder farming, also has implications and possible downsides. The uncontrolled spread of seemingly 'pump-for-free' technologies may pose a risk of aquifer over-abstraction [30]. Excessive reliance on groundwater sources is likely to exacerbate climate change impacts and diminish the resilience of local populations [31]. Depending on the type of water source and pumping intake, it may also become a severe

threat to aquatic life and ecosystems [32]. Less evidently, sudden (massive) introduction of off-the-grid technologies may create disturbances and/or shocks in local energy markets, which may affect the most impoverished households [30]. These implications, albeit beyond the scope of the present work, are certainly worth considering for future research and relevant agricultural policymaking.

In conclusion, the presented toolkit still has a long way ahead. It requires thorough testing with a larger diversity of actors and contexts. Additionally, and given the dynamics of technology adoption, the toolkit must not become a finished package at any given point, but rather a product that needs to be dynamically adjusted over time and across latitudes. In this sense, this has been a first attempt to set the thick lines of a holistic, participatory discussion on the adoption of RE-pumps for smallholder irrigation. Future iterations will offer grounds to keep adjusting it to more specific needs and situations.

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Proceeding Paper

Localizing SDGs in Thailand: Towards a More Inclusive National Science, Research, and Innovation (SRI) Plan †

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Abstract: The Science, Research, and Innovation Plan 2023–2027 (SRI Plan) is a national policy that will support researchers to steer Thailand towards a more sustainable path. In contrast to most existing policies, which focus on poverty reduction through economic growth schemes, and national security, Thailand Science, Research, and Innovation (TSRI) aims at balancing the social, economic, and environmental aspects of the SRI Plan. While the TSRI has been incorporating the Sustainable Development Goals (SDGs) into its policies, it realized that there is the need to cater for diverse lives across Thailand. This research aims to support the TSRI in drafting a more inclusive SRI Plan, especially during the COVID-19 outbreak. Through the SDGs' lens, the researchers collaborated with regional investigators to examine the area-specific needs across six regions of Thailand. Given the COVID-19 constraints, the horizon scanning and modified Delphi technique were used to collect data from April 2020 to April 2021. The results obtained from the participants unveiled that, while several issues are shared, each region ranked mostly different issues as their development concerns. The TSRI stands to benefit from these insights by drafting a region-specific national research plan. Regarding the shared concerns, the economic slowdown was ranked as one of the most grievous matters concerning the regions. Interestingly, through the interlinkage approach highlighted by the SDGs, the participants associated this economic problem with other issues unique to their regions, such as multidimensional poverty, loss of tourists due to the global pandemic, and drug-related crimes. Unfortunately, the relevant authorities usually treat these problems as being separate issues. A silos-dominant administrative system, combined with rigid regulations, prevents efficient cooperation. In addition to the economic issues, waste management and water-related problems due to climate change were ranked as significant concerns. Lastly, the participants also viewed injustice and the lack of good governance as drawbacks to sustainable development. From these results, it is evident that TSRI can draft a more inclusive SRI Plan to support research for sustainable development through the SDGs' lens. Indeed, the Plan would reflect a more balanced view of regional needs than those formulated through the usual technocratic techniques.

Keywords: Sustainable Development Goals (SDGs); Agenda 2030; localizing the SDGs; Thailand; policy research; future studies

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1. Introduction

As the Science, Research, and Innovation Plan (SRI Plan) 2020–2022 is scheduled to end in August 2023, the Government of Thailand has appointed the Thailand Science, Research, and Innovation (TSRI), an organization under the Ministry of Higher Education,

Science, Research, and Innovation (MHESI), to draft a new policy, the Science, Research, and Innovation Plan (SRI Plan) 2023–2027, to support researchers and think-tanks academically and financially so that they are able to steer Thailand towards a more-sustainable path [1]. In contrast to most existing policies, which focus heavily on poverty reduction through economic growth schemes, and national security, the TSRI aims at balancing the social, economic, and environmental aspects of development, along with responding to the impacts of the global pandemic of the coronavirus disease 2019 (COVID-19) in the SRI Plan. As an organization that actively promotes the Sustainable Development Goals (SDGs) through research and innovation, the TSRI views the 17 Global Goals and its 5Ps (People, Prosperity, Planet, Peace, and Partnership) as reference frameworks for this endeavour. Indeed, it has been incorporating the SDGs into its research policies. While collecting essential data, the TSRI realized that there is the need to cater for diverse lives across the country, engage with other sectors, including academia, and leave no one behind. TSRI, nonetheless, fears that, without solid empirical evidence of regional needs, it may be pressured to align its SRI policy along with the national policy norm. Consequently, the organization commissioned academic institutions to collect data and insights and provide scholastic support in defending its standpoint.

The purpose of this paper is to highlight how the researchers assisted the TSRI in drafting a more inclusive SRI Plan 2023–2027 by highlighting localized needs and focusing on shared concerns along the lines of the 17 Global Goals. To fit the context of Thailand, Goal 5: Gender Equality encompasses all genders, in addition to just equality between males and females. Furthermore, the paper also wants to illustrate that, even with the constrictions posted by COVID-19, data on important development issues can still be obtained through the foresight technique of horizon scanning and the Delphi method.

2. Sustainable Development in Thailand

The concept of sustainable development has a long history. It received its first significant international recognition in 1972 at the United Nations (UN) Conference on Human Environment held in Stockholm, Sweden [2]. The term was further universalized 15 years later in the Report of the World Commission on Environment and Development: Our Common Future (also known as the Brundtland Report), which defined sustainable development as "meeting the needs of the present without compromising the ability of future generations to meet their own needs" [3]. The Brundtland Report investigated numerous concerns that had been raised in the 1960s, and the 1970s, including Rachel Carson's Silent Spring (1962), Garret Hardin's Tragedy of the Commons (1968), Edward Goldsmith and Robert Allen's the Blueprint for Survival (1972), and the Club of Rome's Limits to Growth (1972). Countries, including Thailand, began to take sustainable development more seriously following the UN Conference on Environment and Development (Rio Summit) in 1992 [4], and later the Millennium Development Goals (MDGs) from 2000 to 2015, where the social and economic aspects were mainstreamed alongside the environmental aspect of sustainable development. Finally, in September 2015, the United Nations, along with 193 member states, adopted the Sustainable Development Goals (SDGs), a collection of 17 interlinked Global Goals [5], as a universal call for action to end poverty, eliminate hunger, promote inclusive economic growth, maintain peace and justice in society, protect the environment, and ensure that no one is left behind.

Thailand's development in the past was strongly influenced by neoliberalism [6] and the free-market capitalism model of development or the Washington Consensus [7]. This development trend was evident in the first to the seventh National Economic and Social Development Plans, from 1961 to 1996 [8]. Most policies were overwhelmingly concentrated on economic development and paid less attention to the development of human resources, social welfare systems, gender equality, and the natural environment. While the country enjoyed rapid economic growth, up until the 1997 Asian Financial Crisis, growth-oriented policies brought about problems, such as the depletion of natural resources,

overconsumption, waste management issues, overdependency on foreign markets, lack of good governance, and unequal wealth distribution.

Nowadays, Thailand has adjusted its development to be more in line with sustainable development. The 2017 Constitution of Thailand, as well as other national-level plans, such as the 20-year National Strategy (2018–2037), the Digital Economy and Society Development Plan, the Twelfth National Economic and Social Development Plan (2017–2021) [9] and the Thirteenth National Economic and Social Development Plan (2022–2027) [10], have been drafted with the inclusion of the Sustainable Development Goals (SDGs). Nevertheless, the top-down approach continues to be the norm, and many of the existing plans do not necessarily address people's needs in different regions.

Instead of simply aligning its SRI Plan to the SDGs, the TSRI wants to emphasize the SDGs' principles to support the academic sector better. Unquestionably, the SRI Plan must be inclusive, universal, integrated, and underline the importance of local needs.

3. Methods

Through the SDGs' lens, the researchers collaborated with regional researchers to examine the area-specific needs across six regions of Thailand. These regions are Northern Thailand, Northeast Thailand, Central Thailand, Eastern Thailand, Southern Thailand, and the Three Southern Border Provinces (Figure 1). Given the constraints posted by the COVID-19, horizon scanning and the Delphi method were utilized.

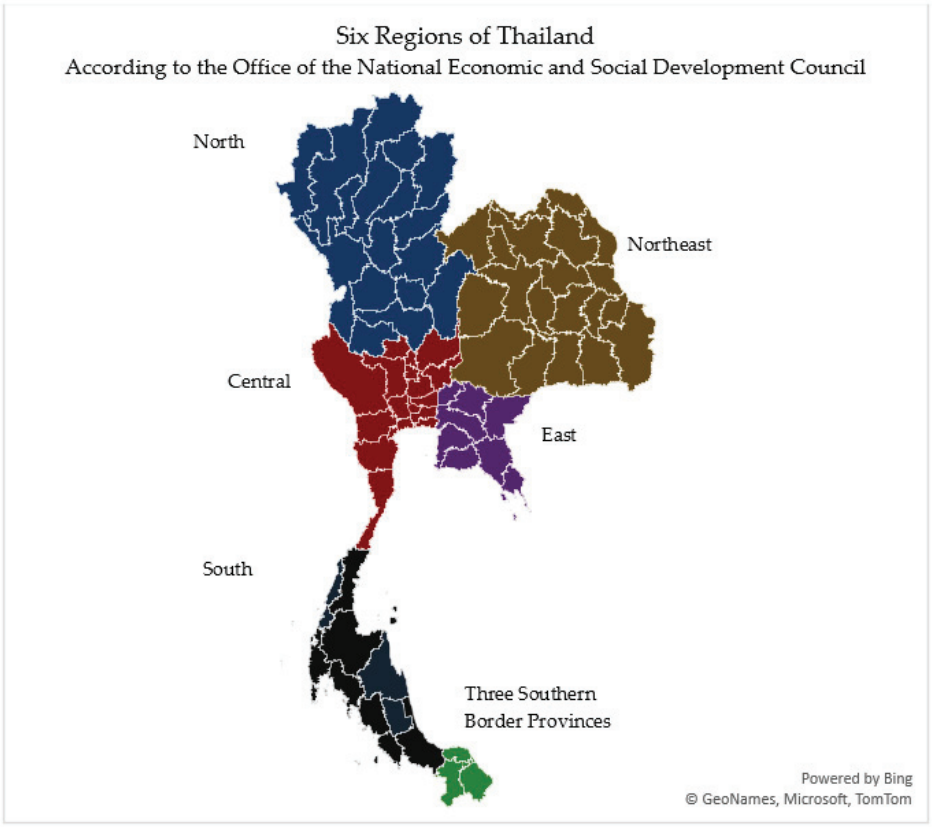

Figure 1. Six Regions of Thailand.

3.1. Horizon Scanning

Horizon scanning, a technique used for "seeking and researching signals of change in the present and their potential future impacts" ([11], p. 2), was conducted from March 2020 to April 2020. The researchers identified themes and keywords for every SDGs by studying 169 Targets and their indicators. These themes and keywords served as a guideline to help the regional research teams to identify SDG-related issues. The researchers examined data to

pinpoint SDG-related issues primarily from four sources. The first source was the National Research Council of Thailand's (NRCT) research database. The second source of data came from international-level and local-level organizations, especially those responsible for providing data on every Global Goal, such as UN agencies, the Asia Development Bank, and the National Statistic Office of Thailand. The quantitative data provided by these organizations enabled the researchers to identify development trends. The third source of information came from online news articles, including mainstream news, alternative news, and local news, in addition to Twitter's trends, from 2017 to 2020. The last source of information was the 20-Year National Strategy 2018–2037, where researchers conducted content analysis to study how different plans would affect the SDGs. Along with these four sources, the six regional research groups obtained additional trends from interacting with regional leaders, officials, and academia.

3.2. Modified Delphi Method

The obtained data from horizon scanning were used to identify SDG-related issues. These issues were utilized in the modified Delphi method, a process used to arrive at a group opinion by surveying a panel of experts without them knowing how other experts responded. Altogether, four rounds of Delphi surveys were conducted to gather adequate opinions on various issues for the TSRI. The benefit of using SDGs as the lens to identify important issues and their root causes is that it forces the experts to think beyond the topic(s) with which they are familiar and consider all aspects of development.

In the first phase of the project, two online Delphi surveys were conducted from May to June 2020. The first round of the Delphi survey was conducted to verify whether the issues that the researchers found, both at the national and regional levels, were pressing regional concerns. In the second round, there were two groups of respondents, those who responded to the national-level-development issues and regional experts who responded to the regional ones. Both groups of respondents were asked to assess the impact of development issues. Simultaneously, they were asked to evaluate the country's readiness to deal with each issue and provide further-relevant information. The results of this phase were also used to help the TSRI to prepare the revised version of the SRI Plan 2020–2022.

The project resumed a few months later, and another two rounds of Delphi surveys were conducted from March to April 2021. National-level issues were integrated into the regional ones, and respondents were asked whether the issues from the first phase of the Delphi process continued to be the concerns in their regions, considering the impacts from COVID-19. Participants could choose whether they wanted to respond to either the issues belonging to the "P" of the 5Ps, to those in which they had the expertise in or to every issue. The researchers from the Eastern Region and the Southern Three Border Provinces were unable to conduct this round of the survey due to time limitations and COVID-19-related constraints. Instead, the local teams of these two regions performed the verification.

Finally, participants in every region were asked to take part in the final round of the Delphi survey to evaluate, out of ten, every issue's severity, impact, and the effectiveness of relevant or existing policies in abating or solving that issue. The researchers evaluated the importance of every issue based on the participants' inputs to rank the development needs of every region, using Equation (1):

$$\text{Importance} = \text{Severity} + \text{Impact} - \text{Effectiveness of relevant policies} \quad (1)$$

Throughout the Delphi processes, the researchers tried to ensure the diversity of the experts participating in this study. While almost half of the experts who participated in this study belong to the public sector, the other half of the participants belong to the private sector, civil society organizations (CSOs), and the academic sector. Different groups of people, such as the elderly, people with disabilities, youth, and LGBTQI, were included in the study. Regrettably, due to time limitations and the constraints posted by the COVID-19 pandemic, the researchers could not recruit many people with disabilities, youth, and

LGBTQI to participate in this study. This underrepresentation might have affected the results of this study.

4. Results

Due to the nature of this research, the results of this study are vast. Only significant results are presented in this paper.

4.1. Results from Horizon Scanning

The researchers conducted the SDG analysis of the National Research Council of Thailand (NRCT) research in 2020. The result is shown in Figure 2. Indeed, an overwhelming number of works are within the purviews of Goal 3: Good Health and Well Being, Goal 8: Decent Work and Economic Growth, Goal 2: Zero Hunger, Goal 9: Industry, Innovation and Infrastructure, and Goal 11: Sustainable Cities and Communities. Goals belonging to Planet (the environmental aspect of sustainable development) generally receive less attention. Still, the two Goals with the least amount of research are in the People (or social aspect of sustainable development). These two Goals are Goal 1: No Poverty and Goal 5: Gender Equality.

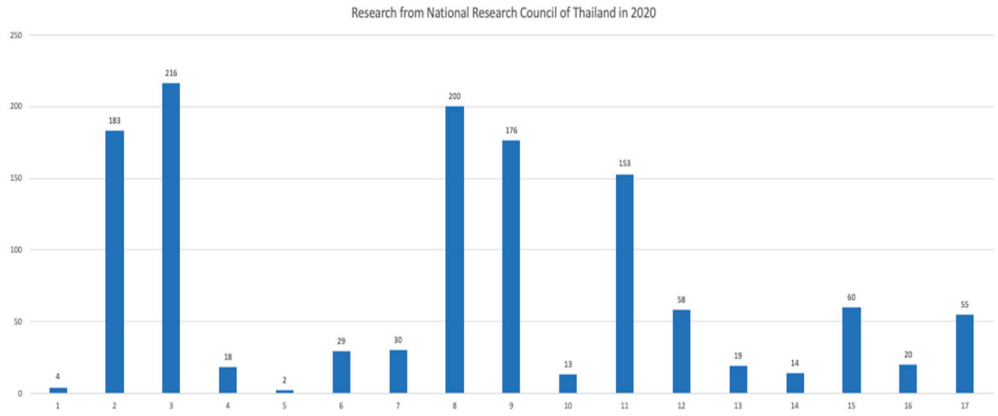

Figure 2. Research from the National Research Council of Thailand.

The researchers analysed 963 online news articles. The contents of 653 articles (67.8%) can be associated with the Goals in the People aspect of the SDGs. In comparison, 142 articles (14.7%) can be associated with the Goals in the Prosperity (economic) aspect. Additionally, 118 articles (12.3%) were related to Technology, which the TSRI wanted to highlight in the SRI Plan. Articles having their contents associated with the Goals in the Planet (environmental) aspect of the SDGs are minuscule, with only 50 articles or 5.2%. From these results, it can be deduced that the public is very concerned about the well-being of society. The environment received relatively low emphasis from the fund-granting agency and very low consideration from the public. The results, however, do not necessarily imply that the people are not worried about the environment. Instead, people might perceive environmental problems, such as climate change, as distant problems, or something that is inevitable.

The content analysis of the 20-year National Strategy (2018–2037), more specifically, the Master Plan under National Strategy, the Country Reform Plan, the Twelfth National Economic and Social Development Plan (2017–2021), and the National Security Policy and Plan, unveiled that, while the national plans address the development of all 17 SDGs, an overwhelming weight was placed on Goal 8: Decent Work and Economic Growth and Goal 9: Industry, Innovation and Infrastructure, and outstandingly high on Goal 16: Peace, Justice and Strong Institution. In the research in the National Research Council of Thailand database, there is a low level of importance placed on the People aspect of the SDGs, with Goal 5: Gender Equality being the least-mentioned SDG in the plans.

With these results, in combination with the analysis of quantitative data, the researchers identified a total of 39 issues at the national level. At the regional level, the researchers of every region also identified crucial development issues. These issues were presented to the experts during the Delphi surveys so they could help to cultivate ideas about potential future developments around every issue.

4.2. Results from Delphi Surveys

At the national level, 36 respondents participated in the first round of the Delphi survey, and 51 respondents participated in the second round. It was remarked that experts in the fields relevant to Goal 14: Life Below Water were the most difficult to find. At the regional level, every region maintained that at least 25 respondents participated in the first and second rounds of the Delphi survey. For the third round of the Delphi survey, there were a total of 472 respondents that participated. In the last round of the Delphi survey, 557 respondents took part. There were about 100 respondents who participated in all four rounds of the Delphi survey.

Following the four rounds of the Delphi survey, the top ten important development issues of the Northern Region are harmful particulate pollution (PM2.5), climate-change-related disasters, food insecurity, land ownership disputes, deforestation and the need for forest management, waste management, unsustainable farming practices, drought, unequal-opportunity educational system, and insufficient access to resources and welfare facilities, in order of importance.

The ten most pressing development issues of the Northeastern Region are poverty, inequality, low level of human development, drought, waste management, violence and injustice, slow economic growth, inadequate agricultural-supporting facilities, the uncertain change of lifestyle due to modernization, and food insecurity, in order of importance.

The most evident development issues of the Central Region, where the Bangkok Metropolitan Region lies, are the contraction of the tourism industry, increasing drug-related crimes, swelling household debts, slow economic growth, communicable diseases (including COVID-19), poverty, the inequitable distribution of wealth, the low level of fair access to farming technology, air pollution, and the lack good governance, in order of importance.

As for the issues concerning the development of the Eastern Region, where the Eastern Economic Corridor (EEC) is located, industrial waste management, drought, climate-change-related disasters, loss of mangrove forests, marine pollution, low-quality water supply, expensive raw materials and that are often in short supply for industrial production, household debts, the shortage of recycling facilities, and food insecurity (due to drought) stand out as the most-glaring concerns, in order of importance.

As for the Southern Region, the development issues of the most-pressing concern are waste management, rapid contraction of the tourism industry (due to COVID-19), spiralling drug-related crimes, poverty, the prevalent destruction of the ecosystem, the perennial lack of good governance, the continuing degradation of the morals of children and youths, inequality and inequity, the education system that does not fit the local context, and drought, in order of importance.

Finally, the most prominent development issues of the Three Southern Border Provinces are the increasing tumour of the widespread incidence of drug-related crimes, the flawed system of the administration of peace, injustice, human rights violation, poor quality education, reduced border trade, widespread unemployment among return-workforce from Malaysia and the Middle East (due to COVID-19), slow economic growth, the shrinking base of the agricultural sector of the economy, continual violence against the citizens, and the impacts of decade-long unrest on youth and children, in order of importance.

When compared important issues to the SDGs, 10 out of 60 issues were development issues related to Goal 8, and 9 were issues relevant to Goal 16. The three SDGs that did not have serious development issues in all six regions are Goal 5: Gender Equality, Goal 7: Affordable and Clean Energy, and Goal 17: Partnerships for the Goals.

5. Discussion

5.1. Trends from Horizon Scanning

While the trends are used mainly to formulate the Delphi survey, the results of the horizon scanning can provide crucial information for the TSRI. Based on the analysis of the NRCT research (Figure 2), a lot of research fell within the economic aspect of development (Goal 8, Goal 9, and Goal 11). This high number of research on the economic element aligned with the priority of most government agencies, which advocates for economic growth. Furthermore, since many Thai people continue to engage in agricultural activities, substantial supports for research to improve productivities and improve farmers' livelihood (Goal 2) was anticipated.

Similarly, from the same analysis, there is no surprise that there were many health-related research endeavours (Goal 3) since there is a growing demand for health care locally and from abroad, in addition to strong government support [12]. Likewise, with the COVID-19 pandemic, it is expected that the funding for healthcare, nursing, and medical research will continue to rise.

A low amount of research on poverty reduction (Goal 1) and gender equality (Goal 5) is not unexpected. It has been a general belief among economists that economic growth benefits nearly all citizens of a country and would reduce poverty. Sadly, economic growth does not guarantee that poverty will be lessened. Many other problems, such as the unfair distribution of wealth, continue to keep many people in poverty [13]. In this manner, it might be beneficial for the TSRI to support and sway more researchers to focus on finding the root causes of poverty that are unique to different regions and explore more deeply the issues of the fair distribution of wealth. Such research would also fit in with the general trend of the public, based on the results from the analysis of news articles and Twitter trends. Vital information gathered from the news articles and Twitter trend indicated that many people were concerned with the twin problem of inequality and inequity, the unfair domination of certain businesses entities, and the lack of good governance that would make it hard for many people to escape poverty.

Regarding the point on gender-based issues (Goal 5), despite a low amount of research, there was a clear spike in conversation on gender rights and equality in Thailand in the past few years. This growth is likely due to the rise of feminism across the globe, in addition to the legalization of same-sex marriage in Taiwan [14,15]. However, intriguingly, many people in Thailand believe that gender equality is not a concern. Women are generally viewed as equal to men, and society essentially accepts LGBTQI. Regarding women's rights, many people do not consider that there is any problem since women have as much say in socio-economic matters. In fact, women hold a more significant percentage of senior leadership positions than the average in the Asia-Pacific region and globally. In 2020, official data indicated that women in Thailand held 32% of senior leadership positions, while globally, women held 27%, and 26% in the Asia-Pacific region [16]. Nonetheless, participants cited that gender-related problems existed in Thailand. Some women still face discrimination and exploitation. These women usually live in rural and minority-dominated areas. While Thai women are performing well in the socio-economic arenas, this is not the case for the political scene. There is a low percentage of women holding political power in the parliament. Thus, women's concerns are often not included in many policies. TSRI should include the themes in Goal 5 into its SRI policy. It should pay particular attention to the more impoverished areas in the Northeast Region, as well as some areas of the Northern Region and the Three Border Provinces where there is a high proportion of minorities.

Finally, all trends reveal low concern for the environmental-centred aspects of the SDGs. Considering that many problems are direct consequences of climate change, this trend is worrisome. The low conversation among the public and the lack of support from the government indicate that, while there may be an awareness that climate change is happening, the awareness of what ought to be done and that everybody is responsible for adapting to climate change remains low. This result should prompt the TSRI that future

research on climate change should not be just about scientific findings on climate change or new adaptation technology. Research on communication and ways to disseminate facts and finding means to convince the authorities and the people to act radically become crucial.

5.2. Results from Delphi Surveys

The results of the Delphi method unveil many development issues that would benefit the TSRI in drafting a more inclusive SRI Plan. Through the surveys, experts describe different consequences and even different root causes. Many identified issues are extraordinarily complicated and are often associated with other aspects of development. This paper will illustrate some of the shared issues, highlighting some of the differences and how they will affect other issues. It is ironic that, while most policies and concerns were geared towards economic growth, as well as improving peace and justice, through Delphi surveys, participants identified many important issues that hinder the success of Goal 8: Decent Work and Economic Growth and Goal 16: Peace, Justice and Strong Institution (Figure 3).

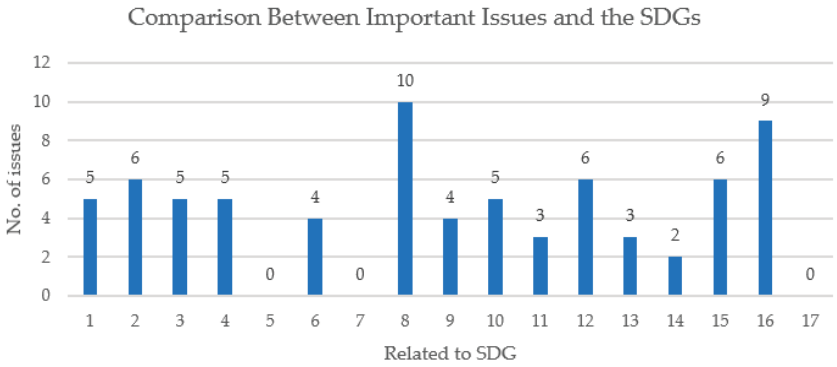

Figure 3. Comparison between important issues and the SDGs.

Experts from five out of six regions rated economic-related issues as one of the most pressing development issues. The problem with the current system is that most policymakers often fail to see the linkage among the different problems. Even if they do, a silo structure within government organizations dissuades officials from working cooperatively across agencies, concentrating instead on their priorities [17]. Many policies are also drafted by those in Bangkok, who might not even know the reality of many people across the six regions. For instance, while the country suffered from the consequences of the COVID-19 pandemic, the associated economic slowdown did not affect everyone uniformly. Yet, most policies were not designed to accommodate these differences. This lack of consideration was evident through the government's efforts to support its citizens and encourage more spending to facilitate economic activities. Government schemes, such as *Khon La Khrueng* (Let us Go Halves), assumed that everyone owned smartphones, had internet access and were familiar with electronic registration and cashless payment [17]. Unfortunately, this was not the case. The poor, people with visual impairment, many elderly individuals, and those who live in remote locations could not enjoy the benefits of this scheme [17].

In addition, many participants feared that impoverished communities in the Northeast, Central, and South would suffer the most from economic slowdown due to the COVID-19 pandemic. Experts from the Southern Region and the Three Border Province also voiced their concerns that economic recession would increase drug trafficking activities along the Thai–Malaysian border and lead to more violence in the areas. Violence in Southern Thailand is usually blamed on terrorism linked to the ethnic and religious separatist insurgency. However, from the Delphi survey, some experts felt that violence in the South and the Three Border Provinces was more likely the result of poverty and the feeling of being left behind, something many policymakers failed to discern. Undeniably, supports for more research in this area are urgently required.

Another vital issue that TSRI must address is unsustainable farming. According to all the rounds of the Delphi survey conducted, there were three agricultural-centred issues that the experts of the Northern Region were concerned about. The experts of the Northeastern Region could not help but stress the more-pressing concerns on hunger and food security. In contrast, the experts of the Central Region were more concerned about unequal access to farming technology, and those of the Three Southern Provinces were more concerned about the shrinking agricultural-based economy. Even though the Eastern Region did not have an agricultural-related matter as one of its top ten most pressing issues, experts did highlight the fact that many farmers in the region, although relatively small in number, were experiencing problems with access to farming technology. Correspondingly, farmers of the Southern Region were experiencing a decline in agricultural outputs due to drought.

Education-related issues were identified in five out of six regions. The SDGs forced the experts to think beyond the issue of quality of education and delve more deeply into matters such as quality of teachers and whether the learning materials fit in with the context of the local economy or highlight environmental protection. In Northern Thailand, experts were concerned that the current education system did not feature the lessons on the cultures of various ethnic groups living in the region. Experts from the Northeast and Eastern Region felt that the current education system failed to sufficiently prepare younger generations to become an efficient workforce, affecting the competitiveness of Thailand on the world stage. Experts of the Southern Region and Three Southern Provinces felt that there was a lack of lessons on good morals and critical thinking.

Furthermore, experts of all regions saw matters concerning the environment as paramount issues. In contrast with policymakers and the public, the experts were concerned with topics such as waste management and the effects of climate change, particularly drought. The adverse effects of improper waste management lead to unpleasant scenes to behold and unleashes negative effects on the overall economy of a country. Communities dependent on the environment also face a significant threat due to the oil spills and the leaching of chemicals, which directly cause soil and water contamination. The burning of any disposed waste and plastic materials results in air pollution, impacting the health of the people. In addition, drought, as an effect from climate change, has already affected all regions. Many people developed anxiety or depression about economic losses. People living in different areas of the country got into conflicts when there was not enough water. Drought causes reduced incomes, fewer recreational activities, and higher incidents of heatstroke.

The last point that many experts of all regions mentioned were good governance. Respondents affirmed emphatically that good governance would accelerate sustainable development in Thailand. During these few years, especially, incidents and cases of high-level corruption, violence and injustice have multiplied. Scholars can support justice-related agencies in finding ways to improve the situation and help to build better governance.

6. Conclusions

Being tasked to draft the Science, Research, and Innovation Plan (SRI Plan) 2023–2027, Thailand Science, Research, and Innovation (TSRI) proposes to balance the social, economic, and environmental aspects of development, along with responding to the impacts of COVID-19 pandemic in the Plan. This paper highlighted how the academic sector assisted the TSRI in drafting a more inclusive SRI Plan by emphasizing localized needs and focusing on shared concerns along the lines of the SDGs.

Through horizon scanning, followed by the Delphi method, the researchers acquired significant trends and development issues in all six regions of the country (Figure 1). The results obtained from the respondents, many of whom are experts in their fields, disclosed that, while each region faces different issues, they are also several shared concerns. For instance, matters concerning economic slowdown were ranked as one of the most worrying issues in all six regions. Nonetheless, through the interlinkage approach stressed by the SDGs, the respondents associated this economic problem with other social, political, and

environmental issues distinctive to each region. These problems include multidimensional poverty, loss of tourists due to COVID-19, and drug-related crimes. Unquestionably, to improve the Thai economy, Thailand must simultaneously unravel the problems that stemmed from poverty, the global pandemic, and drug-related crimes. In terms of poverty, it cannot assume that economic growth will automatically eliminate poverty.

Along with issues associated with the economic slowdown, the respondents also identified many local-specific problems that can be grouped under the lack of sound governance. These issues impede the achievement of Goal 16: Peace, Justice and Strong Institution. Other notable issues include unsustainable farming, education-related concerns, impacts of climate change, particularly drought, and inefficient waste management.

Most respondents recommended that policymakers consider all SDGs to expand their horizons before formulating any policy. Consideration should be given to issues associated with all 17 Goals, even issues, such as gender-related topics highlighted by Goal 5, that the public might not see as grievous problems. It is, however, still rational to prioritize research and innovation to help to alleviate the pressing issues unique to each region. Indeed, the TSRI can use the insights from this research to develop a more sustainable and inclusive SRI Plan.

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environmental sciences proceedings

MDPI

Proceeding Paper

Impact Evaluation of Solar Photovoltaic Electrification: Indigenous Community Case Study in Brazilian Amazon †

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Abstract: Despite efforts to promote universal access to electrification, the Brazilian Amazon basin has around 82,000 families without electricity. The basin is huge, with few roads, many rivers, and conservative areas, which is an enormous challenge in terms of logistics and electrification costs. This paper describes a case study at the Nova Esperança community site in the Cuieiras River, Brazil. The community received stand-alone solar photovoltaic systems in 2018 and 2019. The process started with a survey and finished with an interview with each dweller that received a 975 W and 2-day autonomy photovoltaic system. A monitoring system was developed and deployed, and weather monitoring was performed to evaluate the impact of high temperatures on the equipment. The community does not have cell phone coverage and it is far from the main cities. We claim that the model created and adopted in the case study has interesting outcomes, even considering a small budget. Some houses, after 1 year of deployment, had their electrical demand rise by 300%, and 50% improved their income. We estimate the number of greenhouse gases annually avoided after electrification, replacing the consumed fossil fuel. The project also estimates the expenditure on energy sources that residents used due to the lack of electricity, which they stopped doing after electrification. The avoided expense can cover maintenance costs over the years. The goals of the SDG that were covered by the project are good health and well-being, accessible and clean energy, sustainable cities and communities, combating climate change, and partnerships for the goals.

Keywords: rural electrification; case study; Amazon basin; indigenous community; solar photovoltaic energy

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1. Introduction

The lack of access to clean and accessible energy is considered a central dimension of poverty [1]. Progress has been made, but 10% of the world population had no access to electricity in 2020 [2]. In relation to Brazil, the country faces chronic energy shortages, especially in remote riverside communities in the Amazon basin region, where logistical issues, high demand for investment, low income for the riverine dwellers, and environmental impact are challenging issues.

Besides the efforts to promote universal access to electrification, the Brazilian Amazon basin has yet 82,000 families (350,000 people) without electricity, according to the Brazil Federal Government [3]. However, some sources [4] indicate that this number could reach 3.5% of Brazil's total population, or 990,000 'electrical excluded' people, mainly indigenous people and residents of environmental conservation units. This is a relatively small number, considering Brazil's population, but difficult to reduce, considering the challenges of the

region. Note that Amazon state has only five federal highways and five state highways, the highway BR-174 being the only one that connects the capital, Manaus, to another state, and is passable throughout the year. There are few airports, with only two being enabled for landing and takeoff of large aircraft. In this scenario, it is the rivers and the Amazon waterway network, considered the largest in the world, that constitutes the main means of transport (of people and goods) for residents of the municipalities of the interior and riverside communities.

On one hand, two federal government programs aim to provide access to energy to all through micro-grids and stand-alone systems, through renewable energy sources, or diesel and/or hybrid systems for remote communities in which network connection is not a viable option [5]: the 'Luz para Todos' ("Light for All") federal program since 2003, and the yet unregulated program 'Mais Luz para a Amazônia' ("More Light to the Amazon") since 2020, the goals related to the Amazon basin were underrated and far to be reached. On the other hand, the state program created in 2007, 'Bolsa Floresta' (PBF), aims to encourage the conservation of forests through sustainable use.

The 'Luz para Todos' program was fruitful when the extension of the electric grid was feasible, managing to evolve quickly with the universalization of locations where this modality was possible. However, the difficulties of distance and housing isolation in Amazon basin communities brought a challenge (both logistical and cost-effective) that only the new 'Mais Luz para a Amazônia' program will be able to address. This new program prioritizes low-income families enrolled in Social Programs of the Federal Government, schools, health centers, community water wells, families living in conservation units, rural settlements, indigenous communities, and extractive reserves.

This paper presents a case study of the use of photovoltaic solar energy on an indigenous community of 36 houses in the RDS Puranga Conquista conservative area, distanced around two hours by fast boat from Manaus. The community is accessed only by the Cuieiras River, has a good community organization, and generates income with tourism and crafts. Due to having an elementary and high school, the community has a diesel generator that works 11-h a day, which is maintained by the Education Secretary.

The deployment started in 2018, using individual systems designed according to the electrical demand of the houses, which were previously visited and evaluated for electrical charges. The same 975 Wp solution and 48-h autonomy with lead-acid batteries were adopted in a total of six homes in the period from 2018 to 2019.

The study shows the method for choosing the community and houses to be electrified. The study shows the project with solar photovoltaic energy and contemplates a local monitoring system. The electrical charges are presented at the beginning of the project and after 13 months of electrification, as well as the actual consumption of electricity of each house. It is shown how the governance of the energy use of each house occurred, as well as the increase in income in half of the households and its electrical demand, which rose by 300%, and 50% improved their income after the electrification. We estimate the greenhouse gas emissions annually avoided after electrification, as the new source of generation, which is renewable, replaced one that consumed fossil fuel. The project also estimated the expenditure on energy sources that dwellers used due to the lack of electricity, which they stopped doing after electrification. The avoided expense was advised to be used as savings to cover maintenance costs over the years. In the end, it is explained which United Nations Sustainable Development Goals were achieved by the project and leaves clues for similar projects and actions to occur in the Amazon to remove communities from darkness and be able to bring sustainable development to the most remote places in Brazil. The innovativeness of this paper is related to the fact that there is no previous electrification research in this specific area of the Amazon basin, including the post-deployment follow-up and monitoring.

2. Background

This section features information about the protection area of the case study, the target community, and about the project that provided the financial support for the activities.

2.1. SDR Puranga Conquista

The Puranga Conquista Sustainable Development Reserve (SDR) is an environmental conservation unit of 76,936 hectares, created through State Law 4015 of 24 March 2014. It is in the rural area of Manaus and borders the Negro River (Figure 1). It is worth mentioning that 57.3% of the Amazon state area is under protection nowadays [6], and the Amazon biome has 84% of its original coverage intact [7].

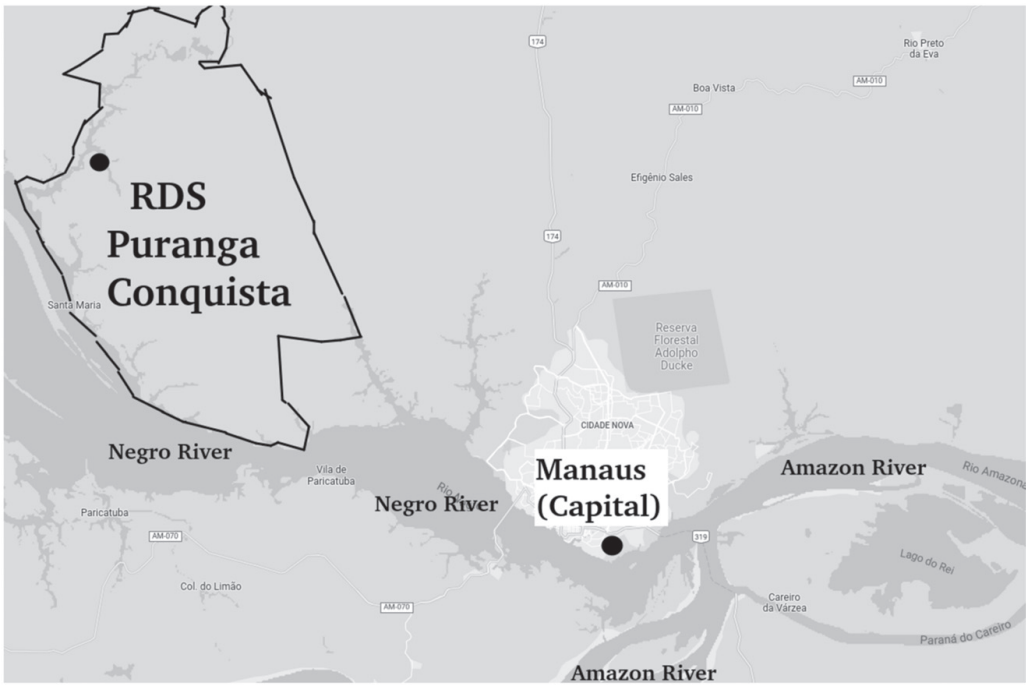


Figure 1. RDS Puranga Conquista (Source: adapted from GoogleMaps).

2.2. Nova Esperança Community

Nova Esperança is located in the SDR Puranga Conquista, bordering the Cuieiras River [8], and has GPS coordinates 2°44′47.8″ S and 60°25′47.4″ W. It is an indigenous community, of Baré ethnicity and, according to its survey of the team in this article, has 36 houses and a state school for elementary and high school, also serving students from nearby communities. During the team's first visit, held in June 2017, a 75 kVA diesel generator was identified, installed, and maintained by the State Department of Education (SEMED) in 2012. This diesel generator is turned ON for about 11 h a day, in school class schedules, and consumes about 50 L of diesel oil per day. However, still in 2018, this generator had technical problems and stopped working, which led to a period of several months with the use of a borrowed and smaller diesel generator so that classes could be performed at school.

The community is about 6 h away by a regional boat from Manaus or about 2 h by fast boat. It does not have cell phone infrastructure, but it does have a satellite internet link at the school. The community was chosen, among the other 14 in the nearby area, because it had an excellent cooperative organization, strong leadership, and because it has craft activities that could be enhanced with the adoption of energy 24 h a day. Figure 2 illustrates the community and its position on the Cuieiras River.

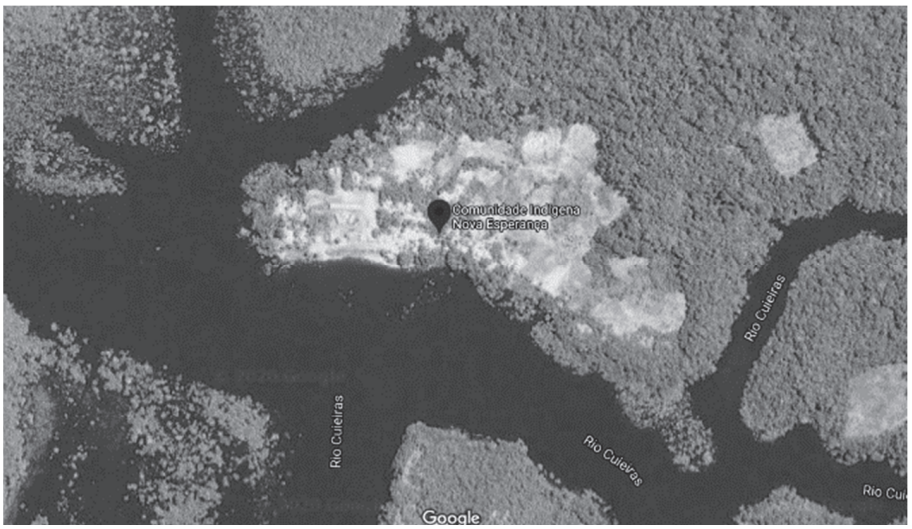


Figure 2. Nova Esperança Community (Source: adapted from GoogleMaps).

2.3. Star Energy Project

The Star Energy project or "Sustainable and Replicable Off-grid Renewable Energy System for Riverside Communities in the Amazon, Brazil", is a project that was executed from April 2017 to March 2019. It involved researchers from Coventry University and the Federal University of Amazonas, in addition to the partners Amazonas Sustainable Foundation (FAS), Schneider Electric, and Scene. It was a project approved under the 2016 British Council's "Institutional Links" public call [9] and had the Newton Fund as its main funder. In total, the project had a budget of £ 60,000, of which £ 18,000 was allocated to equipment (including the electrification and the monitoring system). As an objective, the aim was to electrify a community with a renewable source of energy, to strengthen research in the Brazilian partner through courses and workshops, and to assess the impact of electrification on communities.

3. Methodology

Fifteen riverside communities in three conservation units around Manaus, Amazon State, Brazil were visited. Of these, a total of 14 non-electrified communities were the subject of a survey, conducted in each home, in order to collect data from the resident family, covering 56 questions divided into 9 sections, including data on the homeowner, information on the type of housing, family structure and education of all residents, productive activities, food, health, needs and aspirations, energy assessment (including use of batteries, candles, lamps, and diesel generators) and the electrical demand of the electronics found in an inspection of the house. The questionnaire followed the script of questionnaires prepared by the World Bank [10]. The surveys occurred in June and August of 2017. Due to the budgetary limitations of the project, only one community was chosen (among the 14 where data was collected) and, in total, 6 houses were electrified between the years 2018 and 2019. However, only four of them received a monitoring system for data collection generation and energy consumption. The Nova Esperança community was chosen for presenting the best combination of community organization, the presence of income-generating activity, having a place for team accommodation during field activities (or being close to where there is accommodation), having a school in order to multiply knowledge transferred to residents, and distance to the capital Manaus (considering that several trips were necessary, every month, to enable monitoring of the functioning of the system and collection of data from the monitoring system). The post-monitoring phase includes data analysis and reports.

3.1. Electrification Project

With the chosen community, data from the applied survey in each family were taken and the load curve for each house in the community was estimated. This load curve considers all the equipment found in each place:

- Estimated energy consumption from each one of the surveyed consumer units: 3.6 kWh/day, 9.4 kWh/day, 5.5 kWh/day, 5.9 kWh/day, 7.6 kWh/day, 3.9 kWh/day, 4.3 kWh/day, 2.5 kWh/day, 6.9 kWh/day, 13.7 kWh/day, 4.2 kWh/day, 11.6 kWh/day, 7.9 kWh/day, 0.8 kWh/day, 9.0 kWh/day, 6.6 kWh/day, 5.9 kWh/day, 8.4 kWh/day, 3.8 kWh/day, 1.9 kWh/day (church), 6.4 kWh/day (restaurant), 1.1 kWh/day (craft house), 1.0 kWh/day (hammock house), 1.4 kWh/day (community center), 24.5 kWh/day (school), 6.0 kWh/day (water pump);
- For the closed houses, it was defined a standard load curve of 5.1 kW/day. Here, the dweller was not available to answer the surveys.

From now on, the targeted consumer units will be mentioned here as C-1, C-2, C-3, C-4, C-5, and C-6. Figure 3 illustrates the estimated load curve for some houses that received electrification in Nova Esperança (C-1 and C-2), with a daily energy demand of 3.6 kWh, and 3.2 kWh, respectively. The methodology used for the estimation was to consider an average power consumption during the entire year, without impact from the seasons.

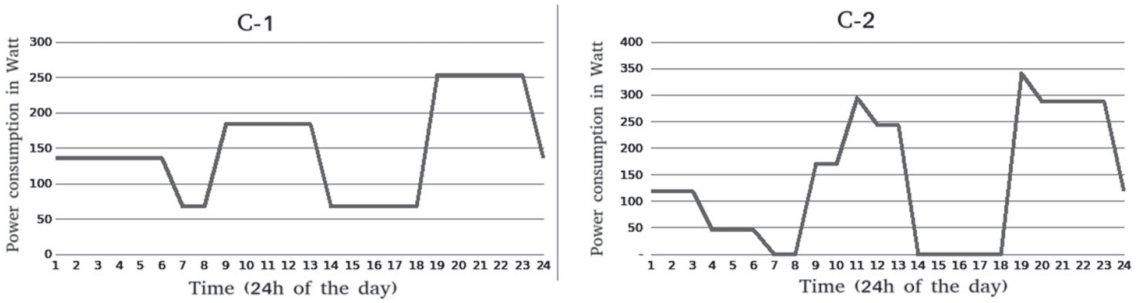


Figure 3. Estimated load curves for C-1 and C-2 in Nova Esperança.

The type of electrification defined was with photovoltaic solar energy and a system of 975 Wp (3 solar panels of 325 W in series) and with an autonomy of 48 h [11], implemented with four 220 Ah lead-acid batteries (2 in series and 2 in parallel) would meet the demand of each house (a single solution that would serve every chosen house). Figure 4 illustrates the diagram of the adopted solution, already grown from the monitoring system developed by the Coventry University team. The choice of lead-acid batteries is based on the price, smaller than lithium batteries besides the lower lifetime.

The monitoring system adopted comprised the Raspberry Pi platform (model 3B), with software specially developed to collect data from the BMV700 battery monitor. In addition to plug-socket type devices for remote monitoring of energy consumption, model MIH005 collects data from consumer electronics connected to it (and the outlet) and transmits them wirelessly to the Raspberry Pi. Among the information collected, we can mention voltage, frequency, active power, reactive power. All data are collected every 10 s and stored on a USB memory locally. Due to the lack of community telecommunications infrastructure, local storage and periodic data collection were necessary.

The installations occurred in two stages: four houses in June 2018 on a 4-day journey and two more houses electrified in July 2019 on a 2-day journey. At the first installation, 3 technicians from the company that supplied the equipment were present, in addition to 3 undergraduate electrical engineering students from UFAM and a professor. In the second installation, only one professor and five students performed the activities.

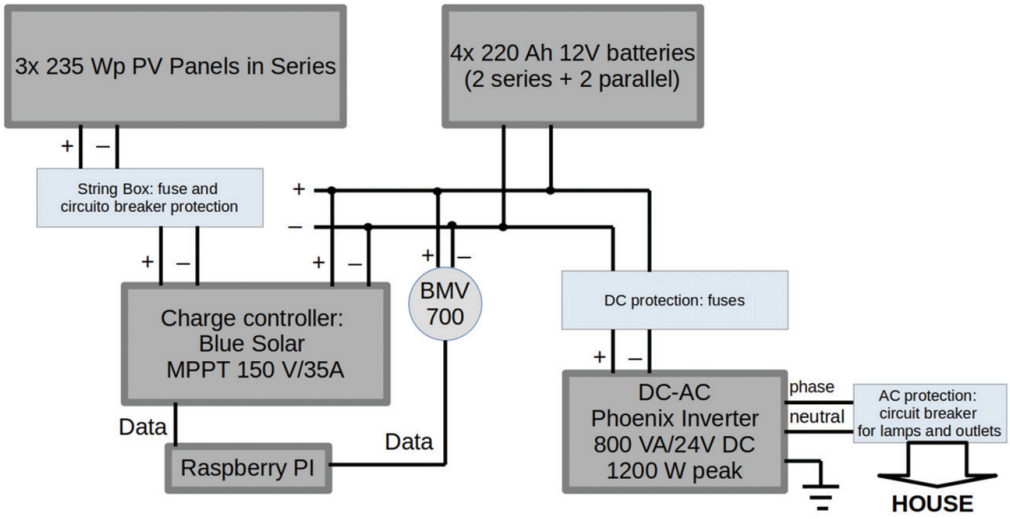


Figure 4. Diagram of the designed electrification and monitoring solution.

3.2. Booklet and Dwellers Teaching

A booklet detailing the functioning of the solar system and energy efficiency measures was prepared. A detail of the booklet can be seen in Figure 5. Several booklets were printed and distributed in the community. They served as a basis for the training given to residents. This training was essential because the dwellers could understand how solar photovoltaic systems work, why it is better to use more energy during daylight, and how to save energy using electrical items smartly.

Figure 5. Booklet produced by the project and distributed in the community.

4. Results

4.1. Related to the Project

We can list the following outcomes:

- Three forms were created to collect data from the communities and the dwellers;
- Three scholarships for undergraduate electrical engineering courses plus one Ph.D. scholarship;
- Fourteen surveyed communities with GPS coordinates and photographs of each house;
- Design of the solar photovoltaic system;
- Design of the monitoring system;
- Deployment of the systems;
- Nine months of visiting;
- Two agreements were signed among the partners;

- Two datasets were built from data collected from the dwellers and the monitoring system.

4.2. Related to the Post Electrification and Monitoring

From July 2018 to March 2019, nine follow-up visits were carried out, with a collection of monitoring data and interviews with residents. The biggest problem encountered was the fact that a dweller frequently reported disarming the system at night, but it turned out that the resident was extending his installation to the neighbor, which had no electricity available. Therefore, the energy demand (of the two houses) was greater than the energy supply. A dweller acquired a 500 W washing machine, but it was explained that, when the resident was going to use it, he should turn off all other equipment and still use the equipment during the day on a sunny day so that the solar system could handle without problems.

It was the responsibility of each resident to rule the use of energy, whether for personal use (well-being) and/or to increase income. The greatest use, at the end of 13 months of follow-up, was shown to be for well-being, whether to add a fan in the house, use of inhalers by children in the house, or to neighbors, to provide comfort. But two houses (33%) started to produce more handicrafts, one of them at night by the artisan who made her children sleep and worked until later. A dweller purchased a refrigerator and started selling frozen fruit food products to the residents of the community, improving the family income. All acquired more electronics. The following behavior of the loads was observed in the four monitored houses, with the growth of 75% to 307% in 13 months: C-1: initial electric charge of 253 W, increased to 734 W; C-2: the initial load of 501 W, increased to 879 W; C-3: the initial load of 263 W, increased to 478 W; C-4: the initial load of 322 W, increased to 900 W in 13 months.

As for the demand for electricity, the residents themselves ended up adapting to the energy intermittence from the photovoltaic system, causing some items to be plugged into the outlet only at specific times and/or days or to be permanently turned off so that the battery power it did not end in the middle of the night. The greater use of energy ended up being primarily for well-being, but 1/3 of the houses ended up generating income from the energy available, producing refrigerated food products or handicrafts.

The monitoring system was an issue that was not solved during the project execution. The Raspberry Pi did not work properly in C-3 and C-4, with many gaps and compromised data. Therefore, the most significant information came from C-1 and C-2 only. On one hand, Figure 6 illustrates the load curve measured for C-1, C-2, and C-4 for specific periods (2 March 2019, 6 January 2019, and 4 April 2019). On the other hand, Figure 7 shows the average daily energy consumption for C-1 and C-2 for the first six months of January; just a few months does not keep up with the general trend of increasing energy consumption (March and April for C-1, and March, April, May for C-2). Related to the C-1 house, the increase in 6 months was 50% for the energy consumption, and for C-2 the increase in consumed energy was 66%.

4.3. Green House Gases Avoided Emissions

The baseline for the estimated greenhouse gases (GHG) avoided after electrification with stand-alone solar photovoltaic came from the information that the diesel generator operates 11 h per day and that it consumes 50 L per day of diesel (for the whole community). The methodology used is from the United Nations Framework Convention on Climate Change booklet CDM (Clean Development Mechanism), specifically the small-scale AMS-I.L methodology, entitled 'Electrification of rural communities using renewable energy' [12]. We calculated the total of GEE emitted and divided by six because we electrified 1/6 of the community in total).

Therefore the total estimate of avoided GHG emissions was of 9.7 tCO_2/year for the six electrified houses in Nova Esperança.

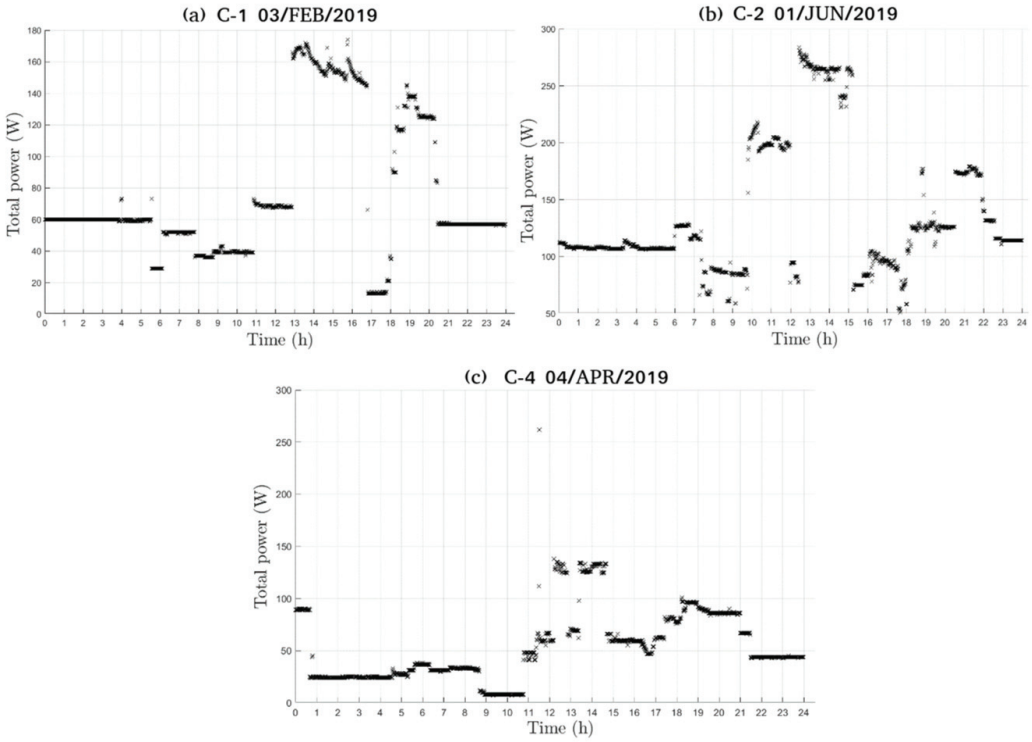
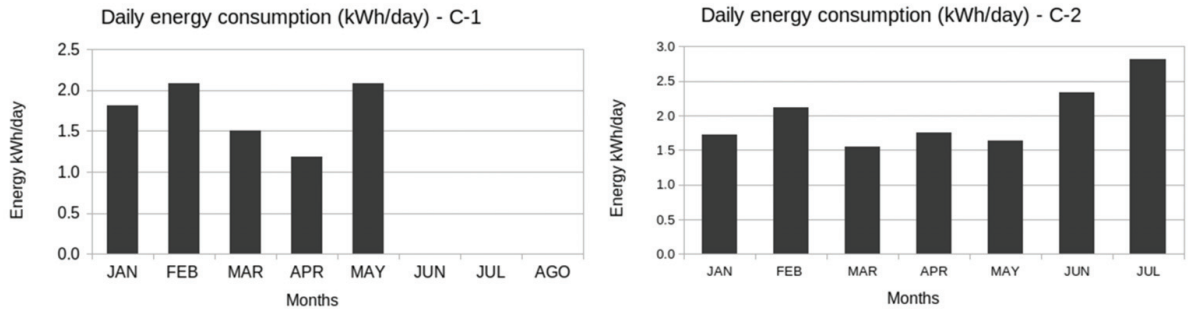


Figure 6. Load curve measured (real) for (**a**) C-1, (**b**) C-2, and (**c**) C-4.



(**a**) (**b**)

Figure 7. Average daily energy consumption evolution for (**a**) C-1, (**b**) C-2.

4.4. Avoided Expenses with Energy after Electrification

Based on the questionnaires applied that contained the number of batteries, fossil fuel, candles, and other items used daily, with their respective market values, due to the need to use flashlights and to have lighting or power generation, it was possible to estimate the total monthly expenditure and annual avoidance for each of the electrified houses. The amounts were converted into US dollars according to the quotation for the month of June 2018 when the electrification in the community began:

- C-1: annual avoidance of US $42.96
- C-2: annual avoidance of US $1800.58
- C-3: annual avoidance of US $687.36
- C-4: annual avoidance of US $702.30
- C-5: annual avoidance of US $44.83
- C-6: annual avoidance of US $1014.23

In total, the dwellers have an avoided expense of US $4292.25 per year. As a recommendation, community leadership can collect this resource and use it to cover maintenance and operating expenses for the stand-alone solar systems, so the dwellers can afford the costs and guarantee the complete working of the systems.

4.5. Temperature and Humidity

A weather station was deployed into the C-1 house, model WH1080 which measures temperature (indoor and outdoor at the same time), humidity, pressure, rainfall, and wind speed (with direction). Based on 2019 six-month data:

- Maximum outdoor temperature: 38.8 °C
- Minimum outdoor temperature: 21.4 °C
- Average outdoor temperature: 27.0 °C
- Maximum indoor temperature: 41.9 °C
- Minimum indoor temperature: 23.7 °C
- Average indoor temperature: 30.6 °C
- Average wind speed: 0.74 km/h
- Maximum humidity: 99%
- Average humidity: 84.6%
- Month rainfall: 61.7 mm

Therefore, the community is in a place where there is high temperature, high humidity, with a low incidence of winds. Considering that the area has no declivity, the water from the Cuieiras river has low speed, therefore the use of hydraulic energy generation is not recommended. Considering the low wind speed, it is not advised to use wind turbines to generate energy. The conclusion is that solar photovoltaic energy is the most indicated in this region.

The fact of the high temperature of work for the photovoltaic system created an impact that was not predicted in advance: the lifetime of the batteries was reduced unexpectedly. The literature states that lead-acid batteries have a 4-year lifetime. However, considering the temperatures faced in the community, the real lifetime of the batteries was 2 years only.

5. Conclusions

Considering the demand for electrification for the Amazon basin, the case study described here serves to produce lessons for future adoption of the universalization of electric energy in the north region of Brazil and for any other rural or riverside communities that are isolated in the great Amazon rainforest that is present in eight countries in South America. We learned about the increase in electric energy demand from the community, the governance of the electricity use, that it is important to teach the dwellers about the type of energy and how to save energy. Technically speaking, the issue with the lifetime of batteries demands more study, probably working with an additional 30% of the autonomy demanded by the batteries in order to compensate for the high temperatures, as the literature states. The avoided expenditure on energy, after electrification, can be a good starting point for the self-sustainability of the community in terms of operation and maintenance costs. The network built during the project, involving academics, NGOs, and the private sector shows that is possible to unite efforts targeting a common goal. The Nova Esperança initiative contributed to goals three (good health and well-being), seven (accessible and clean energy), eleven (sustainable cities and communities), thirteen (combating climate change), and seventeen (partnerships for the goals). It is also worth highlighting the direct relationship that exists between the human development index (HDI) and the availability of 24 h energy in a locality, so it is necessary to encourage the electrification of isolated communities that end up being neglected by universalization programs and by research projects because the logistics and installation costs of the solutions are higher.

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Proceeding Paper

Systems Thinking in a Fluid Environment: SDG 14 and the Ocean-Climate Nexus †

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Abstract: Systems thinking is a mechanism to robustly consider the interconnected world we live in and move away from a 'siloed' approach to policy. Similarly, the SDG goals and targets contained in the UN 2030 Agenda on Sustainable Development require an integrated approach to diverse human and planetary health challenges. This paper contemplates these efforts and then looks to one of the SDGs considered the least interconnected in SDG analyses: that of 'life below water'. It examines the Oceans Goal as part of the SDGs and considers in more detail the process of nexus thinking, in particular as it relates to the ocean-climate nexus. This highlights that there are risks in relying on SDG interaction analysis due to skewed results or a failure to accommodate rapid transformation or knowledge gain in certain fields. We suggest that greater recognition of planetary boundary tipping points will enhance the inclusion of oceans in climate considerations, and improve the likelihood of achieving both SDGs 13 and 14.

Keywords: ocean-climate nexus; SDGs; systems thinking; SDG14 life below water; transformational change; oceans governance; marine policy; international law

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1. Introduction

Both the goals of systems thinking, and the SDGs represent a move toward recognition of the deeply connected world we live in and encourage a move away from a 'siloed' approach to policy. Systems thinking is variously defined, but commonalities highlight interconnectivities and its utility as a tool to understand the role of different elements in relation to the behaviour and outputs of the system [1]. In its preambular language the UN General Assembly describes the 17 SDG goals as 'integrated and indivisible'. It is logical then that the technique of systems thinking be applied to the question of how to holistically consider the SDGs.

The oceans goal is repeatedly considered to be one of the least interconnected of the SDGs. This may not however be an accurate representation of the oceans' relatedness to other goals, and the reasons for this provide useful lessons in considering future SDG interaction analysis. The process of nexus thinking or contemplation of specific linkages between 2 or more SDGs is related. Life under Water, SDG14, in nexus language is most commonly associated with the climate goal. To be sure, the ocean and the climate are fundamentally and inextricably intertwined, both in terms of how they function and their future. The question now is how to engage systems thinking to recognise the danger posed by failing to embrace the ocean-climate nexus.

2. Oceans and SDG 14

The ocean is the main support system for human and planetary wellbeing, and it is increasingly recognised as being in crisis, with a diminishing window of opportunity for

action. It is often reported that the ocean occupies 71% of the surface of the planet, however if considered in terms of liveable space in both breadth and depth then the ocean actually occupies more than 97 per cent [2]. Climate change is the preeminent issue driving change in the oceans, and overall, its effects have been global and manifested rapidly and at larger scales [3]. Oceanic warming, acidification and deoxygenation issues are of critical concern, resulting in major impacts on ecosystem structure, function and service provision as well as being of high regulatory complexity and with large socio-economic impact [4–7]. These alterations in the ocean system are cumulative and often occur at an exponential scale, that is changes in ocean chemistry may not be reversible, especially in terms of gross ecological and ocean processes [2,8–11].

The oceans are contemplated in SDG14 Life Below Water, the goal of which is to 'conserve and sustainably use the oceans, seas and marine resources for sustainable development'. Ocean targets comprise ecological and socioeconomic concerns, including reducing marine pollution (SDG 14.1); restoring marine habitat (SDG 14.2); reducing impacts of ocean acidification (SDG 14.3); eliminate overfishing as well as illegal, unreported and unregulated fishing (SDG 14.4); conserve marine areas (SDG 14.5); eliminate harmful fishing subsidies (SDG 14.6); and increase economic benefits to Small Island Developing States (SIDS) and least developed countries (LDCs) (SDG 14.7).

It is only in recent years that the ocean has been broadly recognised as exhaustible, with previous policy positions equating the immensity of the ocean to inviolability [2]. This is a significant paradigm shift in that it requires an entirely new mindset approach to the management of oceanic resources and conservation approaches. The shift from inexhaustible resource to shared responsibility has been a slow one, due *inter alia* to the common property character of the maritime area, the longstanding nature of extractive interests, the siloed sectoral management systems and complex multilateral governance regime. To be sure, only transformational change will allow for the scale of action needed to keep pace with the escalating impact of humans upon the ocean.

3. Systems and Transformational Change

There is still time left to achieve the sustainable development goals, but it will require an unprecedented global effort and transformational change across all sectors of the economy. Such transformation will also need to go beyond a siloed policy approach and affirmative remedies to symptoms, to address the root cause of our unsustainable socioeconomic structures and political and environmental issues, while enhancing human rights and gender equity [12,13]. To achieve the 2030 Agenda for Sustainable Development, it will also have to go beyond integrating the 169 development indicators into national strategies, and venture into a global context.

Whilst the term 'transformational change' is now being widely used in international sustainability discourse [12,13], and despite many attempts to define it, there is no one commonly agreed definition. A range of general attributes of the processes of transformational change can however be extracted from the wide range of examples in literature:

- Is a highly non-linear process.
- Involves a multi-actor, multi-level approach.
- Explicitly changes the structure or fundamental attributes of a system.
- Large scale system-wide alterations that are sustained over a long period of time.
- Does not imply normativity; moreover, is defined by a transformational goal [14].

Transformational change can be understood as going beyond other types of change, such as incremental change or integrated policy and institutional reform and innovation, however these changes can create the enabling environment for transformational change [13,14]. Efforts to disrupt old path dependencies and forge new paradigms, however, do not inherently lead to positive transformational outcomes towards sustainable development. Similarly, change can be unpredictable, with chains of causal processes often hard to identify.

To help decision-makers target policy interventions and actions that achieve transformational change and avoid unintended consequences, the entire systemic context must be considered [14] and progressive pathways identified [13]. To ensure a better state is achieved from the transformational change, long-term transformational goals should be set, and designed to harmonise planning across climate and sustainable development. In setting such goals for major structural transformations, concepts of planetary boundaries can aid in defining a safe operating space to support natural systems, societal well-being and growth [15].

3.1. Thresholds and Tipping Points

There are various concepts used to describe the constraints of our earth's finite natural resource base, such as 'tipping points', 'sustainable production and consumption' and 'carrying capacity' [15]. The planetary boundaries framework outlines the key limits to seven of earth's life support systems: climate change; biodiversity loss; nitrogen and phosphorus cycles; freshwater use; land system change; ocean acidification; stratospheric ozone depletion; chemical pollution and aerosol loading, can aid in describing such constraints from a necessary global perspective. The interconnected nature of complex systems means that taking this global view will illuminate interactions and overlap of subsystems beyond that of an approach at the local or national level.

Systems planning and understanding of SDG interaction is particularly relevant where action to achieve one SDG may generate a tipping point or system transition that could dramatically affect the ability to achieve another goal [16]. Thresholds and tipping points however remain a central knowledge gap. What is known is that reaching such limits catalyses abrupt change and transition to novel states [17]. There are a number of high-probability high-impact tipping points in the ocean's systems such as warming, acidification and deoxygenation. Low-probability high-impact tipping points include ice sheet instability and circulation changes, which would cause dramatic sea level rise and changes in earth's heat budget respectively [18]. It is critical to monitor and prevent not only abrupt systems change from singular catastrophic events, such as those typically associated with climate-induced tipping points, but also gradual change which can be cumulative, as well as tipping points cascading from other tipping points. Such climate and GHG-induced ocean changes would have a profound impact not only on the marine environment, but on the ecosystem services it provides and as well as society [18].

In order to avoid ocean tipping points, mitigation metrics need to include not only CO_2 concentrations and global mean surface temperatures, but also socio economic targets and confounding ecosystem stressors such as overfishing, pollution and plastic contamination [18]. In this regard SDG modelling needs to identify interactions that are likely to catalyse movement towards tipping points so as to allow policy priority for those thresholds that are most likely to result in irreversible or exponential change, and where the risks of passing a tipping point are catastrophic. Transformational change is needed to prevent systems that are nearing tipping points exceeding their limits and priority must be given to these in any assessment of SDGs. Improved knowledge of thresholds and tipping points would inform understanding of interactions between SDGs and would be crucial to SDG achievement [19]. Interactions of SDGs with extended understanding of planetary boundaries may be a useful way to include otherwise omitted elements from the Agenda 2030 SDG inter relational analysis.

3.2. Obstacles to Transformational Change

There are a range of obstacles to achieving transformational change, with outcomes often hindered by not having a deeper understanding of the impacts of power dynamics—risking further marginalisation of vulnerable groups; policy incoherence; conservative gender norms; inability to sustain change; special interests that reinforce business as usual (BAU) and weakened state capacity including fiscal capacity [12,13]. Furthermore, transformational change must be translated beyond academic concepts and applied into

practice, which will require attention towards not just transformational outcomes, but also related to institutional structures and implementation processes [12]. This shift remains ambiguous [12]. Perhaps the most critical overarching barrier is that the field remains somewhat nascent, with a limited body of research and ongoing questions around what constitutes transformational change, leaving the concept open to potential manipulation and justification of the status quo [12]. Effecting transformational change remains however perhaps the most effective hope we have of correcting systems that are nearing or past tipping points. As such attention needs to be given to understanding the systems and the elements necessary to facilitate transformational shifts.

4. SDGs and Nexus Thinking

The United Nations' 2030 Agenda on Sustainable Development describes the 17 goals and the 169 targets as forming an 'indivisible whole' [20]. They are intended to accelerate an integrated approach to the consideration of diverse human and planetary health challenges. This alignment of the SDGs challenges current sectoral interests, processes and structures. In stating that countries should implement the agenda as a whole, the UN recognises that actions to advance any one SDG will likely affect the achievement of the others and, moreover, that substantial economic, social and environmental benefits will accrue from actions that capitalise on synergies between multiple SDGs [16,21]. Reflecting this, calls have been made for approaches and tools to support increased understanding of the nature and strength of interactions between SDGs, in particular trade-offs, co-benefits and perverse outcomes [22,23]. This is intended to lead to the design of implementation strategies to optimise the effectiveness of actions.

This thinking has led to the development of systems thinking methodologies for how SDGs interact. From this has arisen the nexus language typically applied to the interrelation of two or more SDGs, specifying interactions, and discussing synergies and trade-offs from the perspective of that issue area [24]. Broader attempts at whole of SDG analysis has, by and large, been restricted in application to country specific scenarios. Indeed and notwithstanding the UN emphasis on priority, there have been relatively limited practical advances in methods to understand and prioritise interrelated and systemic approaches to the entire suite of goals, and the properties of the system as a whole are poorly understood [21,25].

There is, to be sure, a high level of complexity in modelling the interactions between such a large number of goals, targets and supporting actions. Early mapping exercises have demonstrated the important interconnections between achieving goals, but experience suggests that government departments and international agencies do not always have the mandate or skills to apply whole of systems thinking or realistically address what might at first appear to be inconvenient and politically contentious trade-offs and unintended consequences. Unfortunately, very little attention has been paid to the institutional structures required to achieve the goals and interactions [26].

A broader concern that has been given very limited attention is the question of the appropriateness of relying upon a series of ultimately politically determined goals to dictate the priorities of human and planetary boundaries into the future. To be sure, although the SDGs were a bold inclusion of environmental imperatives into the precursor Millennium Development Goals and based on scientific premise, the creation of SDGs was an essentially political process [27], the product of which had to be both palatable to governments and achievable within a politically appropriate timeframe. Acknowledging that selection bias exists in SDGs and that they are neither entirely comprehensive nor based on purely scientific needs assessments, allows recognizing that prioritising actions based on these goals alone may lead to non-optimal outcomes. Although intended to be interactive, the use of these targets to prioritise and drive global action in this manner risks additional perverse outcomes through the omission of other equally important factors and actions that were not included in the goals.

As a series of goals and targets, the SDGs do not purport to be prioritised or even inclusive of all identified planetary health needs. Indeed, SDG13 climate is recognised as of preeminent importance [2] but in no way is this reflected in the goals themselves. Adding to this is a recognition of the age of the goals. Several years in the negotiating, and now over five years old, a mechanism for the inclusion of new information, priorities and concerns in areas of rapidly developing understanding such as oceans, is absent. In a time of rapid change, the goals on which we base planetary health decisions need to be adaptive to the inclusion of new knowledge and priorities. Emphasis is placed on the need for 'up-to-date empirical knowledge' on how the goals and interventions of one sector affect another [21]. Though not suggesting a constantly moving framework which would lead to confusion and inaction, such empirical assessment necessarily includes consideration of emerging or escalating issues within the goals. It is important to recall that if a matrix of interactions is not valid then the derived and prioritised actions will be equally invalid [25]. Steps to ameliorate this problem include the integration of planetary boundary measures in Agenda 2030 analyses.

Methodology of SDG Interaction Analysis

Considerable focus has been paid to the identification of synergies or trade-offs among SDGs and the context in which they may occur [21,28,29]. A recognised range of elements are fundamental to any such analysis including that of directionality, strength and necessity, as well as context dependency. To illustrate this one author describes relationships in terms of trade-offs, co-benefits, optionality and context dependence or independence [30]. To date studies that have developed frameworks to examine the interactions among the SDGs, we have applied a range of different classification schemes [21,23–25], although progress has been made in the categorisation of relationships through a widely accepted seven step system [21,23]. Notable in its absence in assessment methodology are the more nuanced aspects of goals and targets such as the level of uncertainty, the irreversibility, temporal and physical scale and the emergence of new knowledge.

Analyses vary in scale: some at the level of goal and others at the level of target. Those done at goal level are broader and more amenable to interpretation. At the target level, much greater specificity occurs and as such substantive interactions are more easily discerned [28]. As such although targets include more detail, they also have the negative element of possibly limiting the analysis to the sphere of the particular targets, whereas goal level analysis may allow for broader interpretation and as such a wider range of linkages to be recognised.

Generally, studies have applied a global forward-looking model-based analysis, with most papers focused on a holistic analysis of the 17 SDGs relying on some form of data mining or expert survey [24,25]. One early exception was a study that applied a textual analysis, which although instructive in the language is unable to contemplate nuanced or implicit linkages in the targets. As such goals that use unique technical language are likely to receive reduced correlations as compared to those with similar descriptors [31]. For example, target 14.3 'Minimise and address the impacts of ocean acidification, including through enhanced scientific cooperation at all levels' shares no textual overlap with SDG 13 relating to climate change. Predictably, model-based studies have revealed additional linkages between goals and targets to that of textual analysis, and confirm that scientifically relevant connections go beyond the targets that are explicitly reflected in the SDGs [31].

The viability of a globally applicable methodology is uncertain. Assessments on SDG interactions, synergies and trade-offs vary widely in their conclusions [16]. Significant issues arise from existing studies where information is derived primarily from systematic literature reviews and expert opinion, including that of data source and participant bias. Methodologies employed means that the quality of the analysis depends on human interpretation and assessment and consequently interactions may be missed, and the true nature of the relationships misunderstood. For example, the scoring of interactions in a cross-impact matrix will reflect the knowledge areas and biases in judgment-based assessors [25]. That

is to acknowledge that scientists too are influenced by worldviews and beliefs [32]. Future assessments would benefit from robust review of data inputs, carefully designed systematic expert selection and use of consensus methodologies such as the Delphi method [16,33,34]. Similarly, reliance on data mining and systematic literature reviews is also susceptible to biases, including those similar to that of direct SDG textual analysis in that some SDGs may have a comparatively low range of cross-disciplinary terminology than occurs between other SDGs. In addition, results will be influenced by the breadth of scholarship in an area and the substantive content produced, and as such the size of a body of work within a discipline may influence how interrelational it appears. To be sure, priorities derived from interaction analysis may reflect biases similar to those that were present in the political process from which the SDGs emerged. This is not to criticise or undermine the validity of such methods but suggest that these methods will be more reliable and robust if enhanced by a systematically comprehensive knowledge and epistemological base.

5. Systems Change in the Ocean-Climate Nexus

5.1. The Interrelationship between the Ocean Other SDGs

In the majority of assessments SDG14 is among the least interconnected of the SDGs [30]. The ocean is immense in size, of fluid nature, with high biological and physical variability. Topic based analysis from extensive multidecadal literature analysis however reveals many more linkages, a result that is supported by expert-based analysis when oceans expertise is engaged in this process [30]. This is in part due to the physical, jurisdictional, logistical and financial difficulties inherent in researching the ocean, which translates to a reduced number of publications and resultant lower occurrence of SDG14 interactions. The need for greater oceans research is recognised in the declaration of the UN Decade of Ocean Science for Sustainable Development (2021–2030). As a research field, the ocean is relatively young, all of which result in an unusually high number of scientific unknowns, and often complex and qualified results. This lack of recognition of connectivity is part of the reason that SDG14 has the least identified progress, and has received the third lowest philanthropic funding of all SDGs [30].

For example, it is seldom recognised in analyses that there are strong co-beneficial linkages between SDG7 'affordable and clean energy' and the oceans goal. These include Target 14.6, wherein successful negotiation of an agreement under the auspices of the World Trade Organisation to eliminate harmful fisheries subsidies, including fossil fuel subsidies, will pave the way for possible broader consideration of the removal of environmentally deleterious fossil fuel subsidies. Similarly offshore wind has emerged as a major source of energy with the potential to power the world's current energy needs 18 times over, and hence there is a strong correlation between oceans and the goal of achieving clean and affordable energy [35]. Additionally emerging wave and tide technologies are one of the few renewable energy sources that are not limited in their continuity of provision. These are rarely represented in SDG matrix assessments. Similarly, SDG14.1 relates to marine plastics pollution which is heavily linked to SDG12 of Responsible Consumption and Production, but also has impacts on phytoplankton's ability to process CO_2 (Climate Action); as well as marine ecosystem health, sustainable fisheries and hence SDG2 on hunger and food security.

Of additional concern in SDG analysis, and highlighted by SDG14, is the limited consideration of the temporal scale beyond its contemplation in terms of deadlines for SDG targets [20,24]. Implicit consideration may occur in the assessment of interactions as the assigned strength of relationship depends heavily on timeframes for change, ranging from real time to those substantial time lags. The problem with only implicitly considering the temporal scale is that we fail to plan for the fact that the longer we pursue unsuitable actions the less likely it is that there is an available pathway to recovery, and the closer we move towards ecological disaster. Herein the reversibility of change is of critical importance. For example, the introduction of plastics or the overharvesting of the ocean

may not have an immediate impact but will create irreversible issues for future poverty and hunger alleviation.

Moreover, also of influence are the governing institutions and frameworks which is the topic of SDG16. Negative impacts are more likely to occur, or be larger, when institutions and rights are weak [28]. This is a form of governance-dependency wherein a negative relationship occurs as the result of poor governance, rather than an intrinsic trade-off itself. For example, fisheries have been associated with ecosystem destruction, however this is a non-genuine trade-off, since the trade-off is not intrinsic to fish extraction but comes from the manner in which it is managed.

5.2. Ocean-Climate Nexus Thinking

Nexus thinking has recently expanded to include ocean-climate interactions. The physical relationship between the climate and ocean is well known, with the ocean having absorbed 93% of anthropogenically generated heat and almost one-third of the CO_2 [36]. Similarly, oceans are heavily linked to climate impact and along with coastal areas are a significant part of adaptation and resilience action. Ocean based industries also offer significant opportunities for emission mitigation and have a substantial role in options for the removal of legacy emission [37]. To be sure the ocean-climate nexus is complex and as with other nexus fields there is a lack of clarity in its meaning, with little explanation beyond highly scientific data or fundamentally superficial definitions. The highest priorities and greatest number of linkages identified in the SDGs relate to climate change and the limiting of temperature rise to 1.5 degree [2]. As related to the marine environment, research paints a dire picture of accelerated ocean heating, reaching depths much greater than previously realised [6,8,9]. Additionally, the ocean as a slow changing environment is particularly prone to difficult to reverse impacts such as changed states of eutrophication and consequential acidification. By the time we address these measures the time for known remedies may have passed. Whilst the ocean-climate nexus has been considered in terms of various needs and opportunities little progress has been made in its organisation and prioritisation.

Emphasis on the need to consider the ocean-climate nexus has come primarily from oceans practitioners across the range of fields. Resistance to this recognition and engagement has been seen from climate practitioners and institutions, and is likely due to a multitude of reasons. It can primarily be explained in systems language as mistaking path dependency with the need to pursue multiple pathways. That is path dependency implies that several equally plausible solutions are possible, and the solution depends on the path that is followed. However, this is not a path dependency scenario and there are not multiple equally plausible solutions. Instead, all possible actions need to occur in order to achieve the desired result of keeping temperatures within the 1.5 degree limit. Climate action requires the simultaneous pursuit of emissions mitigation across sectors and environments, application of nature based solutions, and innovations to capture and store legacy carbon.

This reluctance to engage in ocean-climate nexus issues can be seen within the UNFCCC framework [37]. The climate area is a challenging and complex one, adding to this the additional difficulty of conceptualising oceans, with the multifaceted problems of ocean-atmosphere heat and gas exchange, ocean-atmosphere biological feedback loops, emissions beyond national jurisdiction, a multifaceted and disparate governance system and high comparative level of scientific uncertainty. The reluctance of the UNFCCC to engage in oceans is reflected in the fact that the decision in 2016 to draft the IPCC Special Report on the Ocean and Cryosphere in a Changing Climate (SROCC) came not from the UNFCCC but from the IPCC itself. That is, it was the scientific intergovernmental body, not the governance entity, that recognised the need for engagement with the ocean-climate nexus.

The question is what happens when only one SDG wants to consider an interaction and what are the impacts of reluctance in engagement? Applying a terrestrial lens to climate minimisation in relation to food production (SDG2) and presuming the ocean as a panacea as has been done in the past through assumptions of inexhaustibility will lead to

perverse outcomes and threaten the achievement of multiple SDGs. Whilst acknowledging SDG13 as a priority area with greatest linkages to other SDGs does not however justify a siloed approach. The omission of ocean-based climate action in favour of existing climate priorities will amount to only one result—system failure. That is, 'if the Paris Agreement is to be successful then the ocean must be fully integrated into the climate regime . . . so ocean–climate interactions and consequences are properly recognised and managed' [2].

5.3. Tragedy of the Oceans Commons

One particular challenge that faces systems thinking in relation to SDG14 is the common property nature of oceans and their resources. The 'tragedy of the commons' is a phase applied in the 1960s to the situation of a shared resource that is overexploited due to individuals acting to their own advantage, or failing to realise or choosing to disregard that the net disbenefit would result in the depletion and exhaustion of the resource for all [38]. Tragedy can be applied not only to the over extraction of a resource but also to its overuse as a sink, and thus is relevant also in terms of climate goals.

The concept behind State territorial boundaries is that clarity in legal obligation based on jurisdiction will limit the potential for conflicts over sovereign authority: it is a mechanism designed to maintain peaceful world order. In the maritime context the Law of the Sea Convention prescribes a series of zones of differing jurisdiction. For the purpose of our discussion the most important of these is the 200 nm Exclusive Economic Zone wherein states have the right to exploit the natural resources contained therein with a concomitant responsibility to protect the environment. Beyond this zone is a shared area of ownership referred to as the Area Beyond National Jurisdiction (ABNJ), and covering almost two-thirds of the oceans. Problems arise with respect to such areas precisely because no clear jurisdiction exists [39]. Though long recognised as an issue in oceans management, little has been done to redress the problem and different uses are managed in a siloed piecemeal fashion. Even current negotiations relating to ABNJ are oriented on a sectoral basis, through fisheries, deep seabed mining or biodiversity forums. Transformational change is needed in the approach taken to managing economic activities in ABNJ [2], wherein biodiversity and ecosystem resilience must be at the forefront, and a cross-sectoral approach to policy, planning and management is developed. Without an integrated functional governance through which a common resource can be managed the system as a whole is vulnerable to perverse outcomes. Such an absence, moreover, creates a substantial disincentive and barrier for other regimes to interact in a mutually beneficial manner.

Other issues with the common resources relate to disparity from those that are causing the impact and those that are facing the consequences. In relation to the ocean-climate nexus, it is the SIDS that are likely to face the greatest negative consequences from ocean-climate impacts [40]. This environmental vulnerability means that sustainable ocean development is a priority to these States, however economic vulnerability makes them dependent upon 'international partnerships to address global issues over which it has little control' [26]. Blue economy activities that have negative impacts need to be taxed sufficiently to fully remedy the cost to the global commons [2]. Historically SIDS lacked political power or financial resources, however as one of the most affected regions by climate change SIDS have become a vocal group in the movement to have oceans included in climate change discussions. Indeed, in the context of SDG interactions, the relative lack of links between SDG14 and other goals may be more problematic to SIDS than appears at the global level [31]. With mind to this, more attention should be paid to their calls for ocean-climate action.

5.4. Complexity and System Boundaries

Barriers to the consideration of issues with a high level of uncertainty and complexity have been contemplated above. In terms of systems thinking, the extent to which complex issues are integrated into a system varies greatly, but, as a generalisation, as the number and complexity of interactions increases, so do impediments to the application of systems thinking. Issues of marine sustainable use tend to be complex, and the surrounding

policy process reflects these complexities. The marine environment has a high level of variability in influencing factors and it is often difficult to distinguish between causal relations and correlations.

Although on the surface there is an attraction in understanding the interaction of all 17 SDGs, the validity and utility of this process must be continually reassessed. The earth's functions have no ultimate boundaries, yet to ensure interactions are at a conceptually and functionally manageable level systems thinking requires the creation of boundaries. The goal of understanding whole-of-system interactions may result in information that is so complex that it obscures the outputs [1]. Such complexity may be used nefariously to camouflage inaction when the pursuit of political goals in the national interest are prioritised over globally agreed targets. Translating complex information into effective policy planning and implementation remains an elusive goal [26].

It is essential to remember that system boundaries are however a human construct [1]. The extent to which evidence and logic impact upon a final policy is tempered by political and systematic constraints. Complexity and uncertainty has the effect, in polarised settings, of allowing science to simultaneously validate several opposing arguments. It can be used as both a key lever as well as a barrier to paralyse policy decisions, and cause the premature closure or exclusion of an issue. The extent of scientific influence is highly dependent upon the 'organisation of the relationship between science and politics' [41]. This relates to the malfunctioning of the communications process between policy makers and the scientific community, as well as the determinative influence of the structure and role of the particular institutions involved. Even where ideal conditions exist for the successful translation of scientific advice into a policy position, the ultimate solution for human society is political and expressed as policy [42].

5.5. The Barrier of Uncoordinated or Disparate Governance

International regimes vary considerably according to their scope and form, the level of adherence and the instruments through which they are given effect, as well as their administrative arrangements, budgets and resources. Whilst SDG linkage analysis can assist in structuring a plan for realising the goals [43] without transformational change this necessarily sits within existing frameworks of operation, and both national and intergovernmental responses will be impacted by both competing priorities and limited budgets [25]. The importance of institutions and regulatory frameworks is recognised in Goals 16 and 17 though are predominantly at the national level, with inadequate contemplation at the global scale.

A governance system may be fit for purpose for managing a single sector and yet overly complex when needing to interact with other SDG sectors. As such 'an emerging major research theme in sustainability science is determining appropriate and interconnected governance structures to achieve such multi-attribute goals within very complex systems' [26]. Although often discussed in the national context [26] this applies equally to the UN system of international governance which lacks any mechanism by which those universally consistent co-benefits and trade-offs among the SDGs can be contemplated or negotiated.

Indeed, the global ocean governance framework is highly fragmented. As such attention to the ocean-climate nexus has primarily been directed through the UNFCCC process as this offers a single coordination point. Consequently, oceans have had to justify their inclusion in the process, which has to date met with limited success [44]. Unlike the Executive of the UNFCCC, the UN Special Envoy for the Oceans does not have access to the breadth of institutional support afforded their climate counterpart. In addition, ocean literacy remains poor and enhanced capacity building and awareness raising are needed to support the implementation of SDG14 at all levels [28]. It is for this combination of reasons that, although inextricably linked, climate has both public and political priority over oceans warming.

6. Conclusions

Systems thinking is a range of things including a basis for a science-policy dialogue, a tool for policy coherence and a means by which to prioritise for efficient and effective action. Systems thinking, however, is only as good as the systems definition and there are risks if we get this wrong. Research that disentangles interaction amongst the SDGs can provide for better policy decisions, less unintended consequences, higher probability of goal realisation.

Whilst intended to benefit SDG implementation, assessments of SDG interaction and assignment of priority based on this measure must be approached cautiously. Recognising that existing methodologies and metrics may skew results away from demonstrating need, additional considerations such as irreversibility ought to be included in assessments. Additionally, there is a danger in accepting an analysis as fixed, especially in quickly transforming fields (such as climate innovation) and those with rapid knowledge gain (such as oceans).

Whilst agreeing that international collaboration must give primacy to action on climate change, the impact of such action is diminished when it does not include all the key elements. That is, failure to consider the oceans prevents the realisation of SDG13. Remedying this could take several forms, including alignment within the climate regime of the universally accepted approach to countries boundaries to include maritime areas as contained under the ocean regime [44]; acknowledgement of the complexity, cultivation of greater ocean literacy and acceptance of the scientific communities emphasis on ocean-atmosphere interactions in climate talks; and improved ease of cross communication between ocean and climate through the assurance of a single oceans focal point within both national and international systems.

Going forward a means of ensuring that interdependencies among sectors are taken into consideration may be achieved through the inclusion of planetary boundary thinking. This could accelerate transformative change and lead to the prioritization of issues and nexus areas based on their proximity to reaching planetary tipping points. The need to urgently prioritise action within the ocean-climate nexus would necessarily emerge from such a process. The reality is that irrespective of whether oceans are accepted as a mainstream part of the climate dialogue, a failure to adequately and expeditiously consider the oceans will result in a systemic failure to achieve the 1.5 degree goal.

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Proceeding Paper

Indigenous Multilingual Education in Vhembe, South Africa †

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Abstract: This research with primary school teachers in the Vhembe district of South Africa investigated the role of Tshivenḓa as an Indigenous language of instruction in developing learners' capabilities in education. Interviews with 12 teachers found numerous ways in which teachers drew on their learners' funds of knowledge in Tshivenḓa to connect with their culture, family and community, ensure their emotional well-being and to explain abstract concepts in an inclusive way while enhancing engagement in learning. These findings are significant for addressing Sustainable Development Goal 4 for Quality Education in Vhembe and ensuring Indigenous and minority language children have equitable access to their learning.

Keywords: education; multilingual; mother-tongue; indigenous

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1. Introduction

The United Nations' Sustainable Development Goal (SDG) 4 for Quality Education is challenged by estimates that up to 40% of the world's children do not have the option to learn in their own language [1]. The denial of Indigenous language rights has been part of larger structures of colonization, assimilation, oppression and underdevelopment that the UN's SDG indicators have struggled to capture [2]. This paper therefore links inclusive education in target 4.5 [3] to Indigenous rights of self-determination in schooling under UNDRIP [4]. Leading the way in re-claiming these rights, South Africa made an Indigenous language spoken by around 2% of South Africans one of 11 official languages in its 1996 democratic constitution [5]. With this commitment, Tshivenḓa continues to be chosen as the language of learning and teaching by School Governing Bodies (SGBs), particularly in Vhembe district where the language remains strong.

However, after Tshivenḓa immersion through the Foundation Phase (Grades R to 3), the South African curriculum (CAPS) switches to English as the language of instruction from Grade 4 onwards, and Tshivenḓa is confined to its own siloed subject [6]. While the aim is to create equal access to English as the country's first additional language, this research asks whether this policy supports equitable access to quality education across subject areas. This study explored educators' perceptions of the role of Tshivenḓa language instruction in developing the capabilities of primary school learners in Vhembe, South Africa [7,8].

2. Literature Review

SDG target 4.1 calls for "free, equitable and quality primary and secondary education" [3] (p. 35) that feeds into targets 4.2, 4.3 and 4.4, progressing from early childhood into vocational and tertiary education. As such, primary school education lays the foundation for further learning as children build on their early learning skills [7–9]. Considering the SDGs' call for equity in education, this research asks whether children who grow up speaking Tshivenḓa have inclusive, equitable access to their education [9]. Robeyns (2017)

notes that it is important to identify specific conversion factors which can differ between groups and individuals, to see if a child is able to convert their resources, such as textbooks, into the quality education outcomes schools are aiming for [10,11].

Personal conversion factors include the language(s) one speaks and comprehends. The language repertoire that a child acquires at home and in the community even before entering school is a core resource to communicate and engage them in learning [12,13]. This principle is the basis of South Africa's Foundation Phase language policy [14,15], as well as the latest teaching resources including the UNESCO teacher's guide to reading instruction [16]. Children's home language is rich with their learning from interactions with family and their environment and this is embedded with "knowledge about language and of local beliefs, culture, environment, history, livelihoods, safety and well-being" [16] (p. 14), what Luis Moll (1992) calls 'funds of knowledge' that form an important foundation for teachers to build on for further learning about language and the world [17].

The personal conversion factor of a learners' dynamic English fluency is significant because if the language of instruction is not targeted at an appropriate level, then learners will become frustrated and stop engaging in class [18]. In addition, due to the importance of home language foundation, transitioning to a second language of instruction too early in an 'early exit' model can confuse learners' cognitive development [19]. English submersion teaching is therefore considered poor quality compared to multilingual approaches that include learners' home language [15,17,20,21].

Our language development through childhood is heavily influenced by social conversion factors because the language(s) we speak with friends and family at home and in the community extend our emotional connections to learning. Back et al.'s (2020) work with Park's (2014) notion of 'emotional scaffolding' takes into account emerging multilingual learners' anxiety in engaging in a second language [22]. Back et al. (2020) found strong evidence for alleviating learner anxiety in the classroom and increased interaction in discussions by allowing learners to engage new language and material using their home language through translanguaging techniques. Home language interactions supported learner socialization in the classroom; encouraged them to take ownership of their learning; allowed teachers to better understand and respond to the emotions of their learners; and helped set a cognitive stability that was positive for learning outcomes [22].

Translanguaging involves strategies that are "used purposefully to encourage students to work through a normal process of language-learning, mixing, switching, interpreting, and translating towards being able to use two or more languages" [17] (p.167). The concept builds on the latest research into language of instruction that finds the judicious use of home language with target language is not only successful in second language learning, but also creates a more emotionally grounded learning environment for students [15,22–24]. In addition, translanguaging recognizes the value of exploratory talk where learners translate between their home language and English, demonstrating the cognitive process of bilingualism for the class. Makalela (2016) regards this communicative process, that sees harmony across languages, as consistent with African philosophy, proposing work with ubuntu translanguaging where "one rediscovers a plural vision of interdependence, fluid, and overlapping and discursive system that matches ways of communicating where the use of one language is incomplete without the other" [25] (p. 9). This ethic is taken to heart with the inclusion of Tshivenḓa terminology in the findings of this study.

3. Methodology

The qualitative approach (Scheyvens ed. 2014) used in this research sought to build an understanding of language capabilities in Vhembe in an inductive manner through interviews with 12 teachers who worked at schools across the Vhembe District of Limpopo Province, South Africa [26]. Due to the COVID-19 pandemic preventing international travel, the remote fieldwork relied on relationships with colleagues and educators during the lead author's 3 years teaching in Vhembe and the substantive involvement of Mutshinyani Nesane who acted as a research assistant and cultural advisor. We secured funding for Mut-

shinyani through the Massey University Graduate Research Fund. Mutshinyani provided invaluable experience and assistance in the processes of considering ethical approaches towards how we sought informed consent; recruited participants; conducted interviews; used language in our interviews; transcribed, translated and coded interviews; and finally, how we followed up with participants to confirm findings.

The 12 teachers were identified through a snowball selection technique [27]. Interviews were conducted remotely by mobile phone, establishing contact with teachers through an instant messaging app, setting up an interview time and then calling their phone directly so there would be no costs to the participants. We used an online to landline service to dial South African numbers. Recordings of the interviews were kept on a password protected device with names and identifying details changed for anonymity.

One advantage to conducting interviews during the first COVID-19 national lockdown period was that teachers were at home and seeking outside connections during the global pandemic. Due to the additional time available, participants were eager to talk and share their ideas regarding the study. The drawbacks to digital engagement were the lack of in-person catch-ups that can be very strong in relationship building, and the loss of subtle visual cues and body language that can be important in communication [28].

Following the first round of interviews, participants were asked to engage in follow up conversations so that they could be involved in confirming statements, reflecting on their meaning and giving feedback on the results [29]. This meant that once transcripts were written up, they were shared and discussed with the teachers. During this process, we shared our interpretation of these results and asked for feedback [30]. The teachers were happy to see their own statements as quotes, and backed their inclusion in this work.

The interview questions and their subsequent analysis built on Sen (1999) and Nussbaum's (2011) capabilities approach [7,8], and the methodologies of Yap & Yu (2016) and Walker (2009) [31,32]. The interviews thereby sought to establish (a) the valued capabilities for primary education in Vhembe, South Africa, (b) conversion factors that determined learners' success and challenges in attaining these capabilities, and (c) how Tshivenḓa fit into these wider aims towards quality education [31,32].

4. Findings

This section begins with teachers' discussion about those skills and values that are important for learners to acquire in their primary schools. The successes and challenges to teaching these centered around the diversity of learners in the classroom, the language learners understood, the influence of their parents and family life, the emotions children felt at school, their language attitudes, and providing practical activities for learners to connect to their lessons. Discussions with teachers found that even as learners' English abilities increased, Tshivenḓa retained a key role in their classrooms because it was the one that all learners understood well; that connected to their relationships with parents and grandparents; that supported emotional well-being; and finally, as the language that allowed teachers to communicate abstract concepts through the language of learners' cultural and environmental context.

Teachers in Vhembe encountered various successes and challenges in helping their learners attain valued capabilities in their education. While learners differed in preferences and ability, including special needs and learners who picked up English quickly, Tshivenḓa remained the language of inclusion that all learners were able to understand. By using their learners' home language in the classroom, teachers were able to ensure they remained grounded in knowledge about their culture and themselves, connecting to their relationships with their parents and grandparents at home, bringing in emotions of u vhofolowa (to feel free), u difulufhela (to feel confident), u takalela (to enjoy), and u dihudza (to be proud) at school.

Tshivenḓa was valued as a core part of a learners' life and without knowledge of their own culture and origins their learners would be lost, in a figurative and psychological sense. Tshivenḓa is valued in and of itself as the source of culture and identity. The intrinsic nature

of Tshivenḓa to both the teachers and their learners is also expressed in the consequences of its loss: *"If you take a language from a person, aaiih, you have taken everything [from] that person, because a language makes us who we are" (VB).*

"*Our learners must learn their language, their mother-tongue... you know your culture through your language...they can be able to learn where they come from, where is their home, through their language Tshivenḓa*" *(VI).* One of the ways that families pass on this knowledge is by u dzedza, to tell stories by the cooking fire, such as the lungano folktales that contain lessons for children that are centered in their Venda culture.

More than learning about an abstract past, the language is relevant to learners everyday as Tshivenḓa is central to *vhudavidzani havhudi*, good communication in learners' living relationships with their family at home and elders in the community: *"if the learners don't know their home language I think they will lose communication with their parents or their grandmother at home" (VG).* It is also the language of clearest communication. As one teacher said quite simply: *"It is their mother-tongue, they know that they can understand everything" (VH).*

Tshivenḓa is therefore valued as a core part of a learners' life, how they understand themselves, their origins and their culture through their relationships with their parents, grandparents and teachers at school. In addition, Tshivenḓa tied together many of the emotional threads in a learner's life, between their family, culture, creativity, literacy and motivation in class: *"If the learners are learning their language neh, and if they also learn their culture, they will be happy, even when they [are] dancing and singing, they show that they are understanding what they are dancing for. They even, those older ones, they can even teach the younger ones. Even when we go to the class, if I did the learners to do a composition about one of your cultural dances, it is simple for them to write because they learn from practice. It is simple. For us, that dance, it goes further" (VE).*

This example shows the rich connections between emotion, culture and *u shuma rothe*, 'working together' across the age groups, and learning. By providing opportunities for learners to engage not only in Tshivenḓa but in Venda forms of learning through *u tshina*, dance, teachers encourage them *u difulufhela*—to be confident in themselves, where they come from and their abilities. The singing and dancing brought learners together *u dzhenelela*, to participate, and *u shuma rothe*, work together, and teachers spoke of how activating these connections allowed learners *u tevhela*, to follow and succeed in their learning. Note that many of the words teachers used to describe their learners' emotions working in Tshivenḓa such as *u difulufhela* (to be confident), *u takalela* (to enjoy) and *u tevhela* (to follow and succeed) are conjugated in the relational tense (*-ela*) suggesting that these were not outcomes learners gained individually but in relation to how their class interacted together collectively. Teachers also identified that a common strength in communication between learners was their command of Tshivenḓa language. Tshivenḓa therefore played an important role in the inclusiveness of the classroom. *"You can only find one learner [who is struggling with Tshivenḓa]. And it is not hard to help that one, really it is his or her own mother tongue so really it's easy to support that learner" (VK).*

When discussing the successes and challenges they face in the classroom, teachers created a strong theme around the diversity of their learners. Learners differed in their abilities, some learning faster and others more slowly, some with special needs, some learners received more support from home and all of their learners differed in their aspirations and what they were interested in learning about: *"Learners are not the same, hence each and every learner must learn in their pace" (VA).*

As the language that learners understood, Tshivenḓa was a medium through which learners were able to learn new concepts. This was dynamic as learners became proficient in their new subjects, with each learner at their own pace, and Tshivenḓa retained a role in connecting to learners' prior knowledge across the subjects: *"When we start teaching them . . . something new, if they start from familiar territory then after that you can introduce new things. Like they say we learn things starting simple to the more complex. So starting from what you know it's ok, but if you start where you don't know you can become lost forever" (VH).*

Understanding that some learners move faster than others, the language of learning and teaching also affects how different learners engage content. VF makes the point that Tshivenḓa is a more inclusive language in her classroom: *"They participate more than when we do that in English. Because when we do that in English, [only] the learners [who] will understand it well are the ones who will participate and ask questions. But the whole class will participate if we translate in Tshivenḓa because they understand it" (VF).*

Importantly, the teachers also noted that not only were more learners participating in class, but that learners also demonstrated higher levels of critical thinking when they engaged in Tshivenḓa: *"In Tshivenḓa it's where you can hear exactly what they want to say and even their questions are well structured" (VH). "It's that they think in Tshivenḓa. They participate intellectually mostly in Tshivenḓa" (VD).*

This critical engagement that teachers described with children in Tshivenḓa would seem to be at risk with the switch to English as the language of learning and teaching in Grade 4. However, this research found that teachers were pragmatic and they continued to provide opportunities for learners to understand and engage in subjects in the higher grades in their home language by code-switching between English and Tshivenḓa. Code-switching was an exercise that teachers described as helping learners understandf more about what they were learning through Tshivenḓa, while also extending their language into English: *"Yeah Tshivenḓa helps a lot because when I teach I have to code switch to Tshivenḓa . . . and tell them some terms using our mother tongue so that they will grasp the topic very well. If I give them using the mother tongue it becomes easier for the learners to understand what is going on rather than using English only" (VI).*

Teachers' need to switch to English was driven by policy, *"Because they will be writing in English, the language of instruction is English" (VF).* Pedagogically, VD insists that despite the policy *"You must not throw away Tshivenḓa because you could throw away the whole content, trying to follow English" (VD).* Still, teachers demonstrated a great amount of togetherness to support the Department of Basic Education (DBE) policy and learners' transition to English. The exception was VA, the only retired teacher, who challenged CAPS' uniform progression. Many quoted the DBE workshops where the current advice is that if teachers must code-switch, they should retain English dominance with 60/40 English/Tshivenḓa: *"When we go for workshops, they will tell us that when we code-switch we mustn't dwell much on the mother-tongue" (VH).* Across this group of teachers, the practice of code-switching varied widely and this was connected to language attitudes. The main factor in whether teachers were comfortable in their code-switching appeared to be the belief, enforced by DBE policy, that English is the language of progress, modernity and knowledge. This view is consistent with the large body of literature that colonial notions of the superiority of English as a language of education allow it to dominate, obscuring post-colonial understandings of Indigenous contributions to sustainable development and preventing teachers from realizing the full benefits of quality multilingual education [12,15,21,33,34].

In summary, the thematic analysis of teacher interviews identified a number of ways in which Tshivenḓa enhanced engagement with their learners. Code-switching into Tshivenḓa had a positive impact on learning because it was the language learners understood well, connected more closely with family, learners' emotions, and was an inclusive language that invited participation and critical thinking [35].

5. Discussion

The South African Constitution (1996) Section 6 establishes Tshivenḓa as an official language and provides for multilingualism and elevating the status of previously marginalized Indigenous languages [5]. The value of the capability to learn and speak Tshivenḓa in schools was unanimous among the teachers interviewed and was consistently backed up by the constitution of South Africa, Department of Education policies and international agreements [1,3–6].

The main aim of the Department of Education's policy for language in education is "to pursue the language policy most supportive of general conceptual growth amongst

learners, and hence to establish additive multilingualism as an approach to language in education" [36]. In the same way that monolingual education instils doubt and limits our capability to learn other languages, multilingual education instils confidence in children that they can engage beyond their home language and, if and when they choose, to become proficient in other languages like English [37].

Teachers were clear that the Grades R-3 Foundation Phase did not provide enough of a language foundation for their learners in Vhembe to transition to English medium instruction in Grade 4. Most teachers' observations were consistent with the literature on multilingual education that learners must be strong in their home language for English fluency to follow [12,38]. One teacher suggested "if we code-switch to English in Grade 3 it would help" (VG), this demonstrates how, in practice, the commitment to Tshivenḓa–English multilingualism can be trapped in one direction and be used to justify an earlier switch to English instruction [39]. These are the power dynamics that continue to confine and minimize Indigenous languages [33,39].

All 12 teachers were clear and consistent in separate interviews that their learners must learn their home language first, and another five teachers asserted that their Tshivenḓa foundation strengthened learners' capability to learn other disciplines, including English. These five teachers' observations are consistent with the seminal work of Cummins on the interdependence of language proficiency [12,40,41] that the policy analysis from the Department of Basic Education (DBE) also used to justify its Foundation Phase home language policy but then inexplicably abandons in Grade 4 [42]. The Grade 4 curriculum is a critical period where learners are beginning to branch out from basic literacy and descriptive language into more abstract concepts of feelings, actions, and consequences in the world around them. Not only does an indiscriminate shift to English-only teaching material cut learners off from using this strong foundation of language, it puts them back into having to learn concrete descriptive language in English, delaying their progression into negotiating more abstract concepts in their education.

Vygotsky's (1978) 'zone of proximal development' (ZPD) is instructive in discussions on the language of instruction because it recognizes the importance of engaging learners' prior knowledge as a way of progressing learners into understanding new concepts [43]. ZPD also recognizes that the aim of education is to push learners beyond their current set of functionings, which CAPS describes as crucial for social transformation [44]. When Vygotsky's ZPD is considered in the multilingual context of this research, learners' linguistic 'aptitudes, abilities and prior knowledge' were described as predominantly being in Tshivenḓa, while many of the new concepts in the current curriculum are in English. The finding that teachers use Tshivenḓa to engage and visualize concepts before moving into English shows a dynamic understanding of languaging through learners' ZPD, engaging learners' prior knowledge and then introducing curricular concepts in English. In this way we can see that the use of Tshivenḓa need not trap learners in their current set of functionings, and is actually a key component in active learning. Embracing learners' linguistic dynamism like this also has the potential for teachers to Translanguage between local/embedded issues in learners lives to global/abstract ideas in their education. This would move closer to fulfilling the South African curriculum's aim "that children acquire and apply knowledge and skills in ways that are meaningful to their own lives. In this regard, the curriculum promotes knowledge in local contexts, while being sensitive to global imperatives" [44] (p.9). The local context in Vhembe is Indigenous, it is in Tshivenḓa, and despite the limits of the curriculum, many of these teachers embrace their learners' funds of knowledge in Tshivenḓa in order to take their learning further.

6. Conclusions

This research has illuminated various ways in which the capability for Indigenous Tshivenḓa language instruction has enhanced both the learning and well-being of children in the classrooms of this group of teachers in Vhembe. Teachers drew on their knowledge of Tshivenḓa to respond to the diversity of their learners in accounts that demonstrated

quality, inclusive education. In this way, teachers' code-switching practices activated familiar concepts for learners in Tshivenḓa and this helped them move together to more abstract concepts in English. This reflected an understanding of progression as working in learners' 'zone of proximal development' moving from the familiar to the new, with teachers underscoring the importance of: knowing your language to have the linguistic foundation to language further [12,40]; knowing your culture to value and respect other cultures [8]; and knowing yourself to have the emotional capabilities for empathy towards other people [12].

In the foundation phase, Tshivenḓa ensured children learned literacy, numeracy and life skills while staying connected not only with their culture and origins but also their parents and grandparents, by learning *vhudavhidzani ha vhudi*, good communication and *thonifho*, respect. Parents *u dzedza,* to tell oral histories such as the *lungano* folktales, and were able to assist creative arts curriculum with *u tshina*, to dance Venda dances such as *tshifhasi.* This active engagement in their culture allowed learners' *u dihudza,* to be proud; *u difulufhela,* to feel confident; and *u takalela,* to enjoy. Through the intermediate phase, teachers expressed how using Tshivenḓa allowed them to engage the full linguistic repertoire of their learners, opening up the agency for children *u vhofolowa,* to feel free; *u shuma rothe,* work together; *u dzhenelela,* to participate, and *u tevhela,* to follow and succeed in the classroom using their home language in math, social science and natural science subjects. This dynamic reflected active learning to the extent that *"they participate intellectually mostly in Tshivenḓa" (VD).* However, teachers' use of Tshivenḓa continues to be marginalised by outdated colonial models of English submersion teaching.

Emerging research in South Africa on ubuntu translanguaging pedagogies promises to build on teachers' instincts that they need to give equitable access to the valued capabilities of both Tshivenḓa and English in the classroom [25]. This research shows that this type of teaching would align far better with the skills and capabilities of local Indigenous teachers who are bilingual, than an English-only curriculum that is unjustifiably suppressing active and inclusive learning through Tshivenḓa in schools and jeopardizing South Africa's achievement towards SDG 4 for Quality Education.

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Proceeding Paper

Combining the Circular Economy, Doughnut Economy, and Permaculture to Create a Holistic Economic Model for Future Generations †

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Abstract: The Circular Economy (CE) is an economic system that integrates economics and the environment to offer a model of sustainability and business opportunity. Whilst the CE has the potential to benefit society, there is a lack of the social aspect being integrated into the current framework. Combining the CE with additional concepts, such as the Doughnut Economy (DE) and Permaculture, creates a more holistic, sustainable approach that aligns with the three pillars of sustainable development: social, environmental, and economic. Bringing together the concepts of the CE, the DE, and Permaculture offers a potential framework that acts as a guideline for businesses and future economic policies to be both environmentally sustainable and socially beneficial. Combining these relevant concepts leads to the development of a future CE that has strong ties to the socially focused Sustainable Development Goals (SDGs) and offers a holistic economic model that is more sustainable for future generations.

Keywords: circular economy; doughnut economy; permaculture; sustainable development; environmental economics; sustainable development goals; sustainability

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1. Economics Today

In order to discuss the current economic model, it is important to understand how economics is defined. Whilst there is no unanimous definition of economics, a commonly accepted explanation is that of Robbins [1] (p. 16), who defines economics as:

> *"the science which studies human behavior as a relationship between ends and scarce means which have alternative uses."*

Others have also defined economics as:

> *"a study of mankind in the ordinary business of life; it examines that part of individual and social action which is most closely connected with the attainment and with the use of the material requisites of well being."* [2] (pp. 1–2)

As well as a:

> *"social science that studies the choices that individuals, businesses, governments, and entire societies make as they cope with scarcity."* [3] (p. 5)

When looking at these three definitions of economics, there are two things that stand out. Firstly, all three definitions mention society and the human dimension (human behavior, social action, societies), secondly, they all mention scarcity and the requisites needed for wellbeing. How scarcity is defined (financial scarcity or resource scarcity) is up for interpretation, but it is not hard to see the link between the scarcity mentioned in these economic definitions and the increasing scarcity of natural resources as a result of the current linear economy.

These definitions appear to suggest that an economic model should consider society and human behaviour in response to the scarcity of resources, yet the current economic model focuses strongly on economic scarcity and how to overcome this whilst ignoring the social aspect of society or the question of resource scarcity. The current economic model puts economic development at the core of business and decision making, often at the expense of the environment and society. This linear model includes three short and destructive stages: take, make, and dispose. It is a model built strongly on fossil fuel inputs, resulting in massive natural resource losses and natural capital depletion [4]. According to the ARUP report '50 Scenarios: four plausible futures', we are on the road towards 2050 being "*shaped by three decades of gradual societal improvement, coupled with half-hearted environmental stewardship*" [5] (p. 48). This is a future in which, by focusing purely on economic growth, both people and the planet suffer.

The top countries in the world for economics are measured by their Gross Domestic Product (GDP) [6]. When a country's economy is measured simply in terms of its GDP whilst disregarding other factors that strongly contribute to its success and wellbeing, is this an accurate representation of a country's true economics? It is not to say that financial stability is not important, but rather that economics and success should also be measured in terms of a country's ability to cope with resource scarcity, including natural resources, and the wellbeing of society. When considering economics in these terms, an economical model should clearly align with the pillars of sustainability: social, economic, and environmental.

2. The Circular Economy

The Circular Economy (CE) is an alternative economic model that focuses on economics and the environment by using cascades and feedback loops to offer an economic model of sustainability and business opportunities [4]. The CE is growing in popularity and momentum and is being adopted across countries, governments, businesses, and institutions, as shown by the EU Circular Economy Action Plan [7], the Circularity Gap Report [8], and the Ellen MacArthur Foundation [9,10].

Cascades and feedback loops allow biological materials to return to the biosphere whilst maximising the value of technical materials and reducing raw material demand through maintenance, reuse, and refurbishment [4]. These loops encourage innovation and increase business opportunities and value creation whilst reducing harm to the environment. A core underlying contributor to the CE is natural capital and the importance of nature within economics [11]. Nature is integrated into the economy by increasing the productivity and life cycle of raw materials and natural resources and shifting towards renewable energies [4,12,13]. In contrast to the linear economy, the CE introduces an economy in which success is measured economically and environmentally [14].

Whilst the CE offers an economic model that integrates the economic and environmental pillars of sustainable development, there is a lack of integration of the social pillar. Murray [15] suggests that social justice and a social dimension should be at the heart of sustainability; however, there is currently no focus on society nor a future suggestion of how the CE could lead to social equality. According to Schroeder [16], the CE has strong relationships with specific Sustainable Development Goals (SDGs) (6, 7, 8, 12, 15), all of which fit closely with the pillars of economy and environment. However, the CE has no links to SDGs 3, 5, 10, 11, and 16, all of which are under the social pillar of sustainability. In addition, research by Padilla-Rivera [17] suggests that social aspects relevant to strategies and impactful actions are not promoted within the CE framework and that without the integration of the social aspect, it is not certain whether the CE is more sustainable for future generations than the current linear model. Padilla-Rivera's review of the CE demonstrates that there is no consensus on an appropriate framework that integrates the economic, social, and environmental aspects, and it is suggested that further studies "*should define and specify how to measure social indicators and how [CE] practices can improve human well-being in society*" [17] (p. 13). Due to this, it can be concluded that, by integrating the

environmental aspect, the CE offers a huge advancement to the current linear economic model; however, for a fully holistic model, the societal pillar needs to be considered.

3. The Doughnut Economy

The Doughnut Economy (DE), developed by Raworth [18], offers an alternative economic model that is inclusive and sustainable. The DE aims to bring together social and environmental aspects into an economic framework to support the development of a thriving world for both people and the planet through the introduction of boundaries. To bring the social side into the economic model, the DE suggests there are societal boundaries, based on the SDGs, which society should stay within in order to meet the needs of all people. The model brings the environment into economics by suggesting that there are planetary boundaries that cannot be crossed in order to ensure that our economic growth is not at the expense of the planet. According to Raworth [19] (p. 217):

> *"Last century's adopted policy goal of never-ending Gross Domestic Product (GDP) growth has been leading us far off course, resulting in economies that are degenerative, running down the living world on which human wellbeing fundamentally depends, and that are also divisive, enriching the 1 per cent at the expense of the rest."*

This model is a stark contrast to the current linear economic model that focuses purely on financial economics and GDP by creating a model that puts people and the planet at the center. The DE asks the question:

> *"How can our city be a home to thriving people, in a thriving place, whilst respecting the wellbeing of all people, and the health of the whole planet?"* [20]

and is responsible for a global transformation of cities, governments, and countries [21].

Whilst the DE is clearly influential in creating a holistic model that is built around society, coping with scarcity, and living within planetary boundaries, it is currently limited to application within the business context. The Doughnut Economics Action Lab [22] currently only allows businesses to use the DE as an internal tool in the organisation of the business. This aims to avoid greenwashing and encourage businesses to truly become regenerative and distributive by design, however, it also means that there is a lack of understanding of how DE can influence businesses and the potential impact on their revenue or the pillar of sustainability: economic. The model offers a clear goal for companies, staying within the doughnut; however, it is limited in terms of how to achieve this. How each company stays within the social and environmental boundaries is dependent on the business, and it requires motivation and innovation from businesses to work out how to do this [23]. Raworth [24] argues that, in order to create a regenerative business and economy, we need to create a circular design through loops in order to transition away from the linear economy. This shows clear parallels with the CE discussed previously; however, it goes one step further by encouraging economics to integrate the social pillar and become regenerative and distributive by design.

4. Permaculture

Permaculture can be defined as an approach to "*design and develop sustainable communities in harmony with natural ecosystems*" [25] (p. 720). Whilst traditionally considered a regenerative agriculture practice, Permaculture has been recently used to develop sustainable social models [26]. According to Genus [27] (p. 1454):

> *"Permaculture is a growing but little researched phenomenon emphasising care for the environment, equity, fair treatment of people and working with—and not against—nature. It thus represents a potential alternative to business as usual, capable of addressing fundamental challenges posed by human-made climate change."*

Entrepreneurs working with Permaculture describe it as:

> *"'a framework', 'a set of ethics', a 'design approach' with which to create resilient ecosystems, societies and cultures that support people to meet their basic needs and that work with nature."* [27] (p. 1460)

By using a set of principles and the ethics of people care, earth care, and fair shares [28], Permaculture offers a framework centered around society and the environment. Although Permaculture is not strongly associated with economics, there is evidence to show it can be applied at the company level as an alternative management system and a basis for sustainable enterprise model innovations [29]. Others also suggest that Permaculture can be used to respond to social issues arising in social economy enterprises [30] and to create regenerative companies [31,32]. According to Macnamara [33], Permaculture is a framework that encourages abundance. When the basis of economics is society and how people cope with scarcity, it seems relevant to explore Permaculture's role in economics. Can Permaculture's focus on abundance contribute to an economic model that, by nature, considers society and the environment and creates the ability to cope with scarcity?

So, why is Permaculture not applied more to economics? Whilst Permaculture is useful in integrating society and the environment and encouraging abundance, there is limited application to the business context and current applications tend to focus on small businesses rather than larger businesses or at the country or government level [27]. In addition, Permaculture is more useful for looking at management and social systems within businesses to create a holistic economic model rather than for financial stability, however, economics also needs to be considered in order for the model to be fully sustainable.

5. The Key Combination

It is clear that the CE, DE, and Permaculture all offer alternative economic models to the current linear model by bringing in the environment and/or society as a key element within economics and responding to the core points of an economic system: society and dealing with the scarcity of resources. Whilst these models offer an alternative, none are fully holistic nor focus on all pillars of sustainability: social, environmental, and economic. Therefore, focusing on them separately does not offer a holistic model:

- CE focuses on the environment and economics;
- DE focuses on the society and the environment;
- Permaculture focuses on the society and the environment.

So, what if these models could be combined to create an economic model that is truly holistic? Perhaps, by combining the CE, the DE, and Permaculture, an economic model can be developed that aligns with all three pillars of sustainability: social, environmental, and economic.

6. Principles

The CE, the DE, and Permaculture all offer an alternative way to look at economics, but do they fit together and are they truly aligned? According to the Ellen MacArthur Foundation [4], the CE is based on a few simple principles. The DE has principles of practice [34], and the co-creator of Permaculture, David Holmgren, developed 12 principles of Permaculture [35]. When looking at these principles across the three models, they are clearly aligned and can be mapped together, as seen in Table 1.

Table 1. Principles of CE, DE, and Permaculture.

Circular Economy [1]	Doughnut Economy [2]	Permaculture [3]
		Observe And Interact
		Catch And Store Energy
	Be Regenerative	Obtain A Yield
		Apply Self-Regulation And Accept Feedback
Rely On Energy From Renewable Sources		Use And Value Renewable Resources And Services
Design Out Waste		Produce No Waste
Waste Is Food		
Think In 'Systems'	Think In Systems	Design From Patterns To Details
	See The Big Picture	
	Be Distributive	Integrate Rather Than Segregate
	Aim To Thrive Rather Than To Grow	Use Small And Slow Solutions
Build Resilience Through Diversity	Nurture Human Nature	Use And Value Diversity
	Embrace The 21st Century Goal	Use The Edges And Value The Margin
		Creatively Use And Respond To Change

[1] Ellen Macarthur Foundation (2012). [2] Doughnut Economics Action Lab (2020). [3] Holmgren (2020).

The principles across the three models draw clear parallels. All three models bring in the importance of thinking in systems and seeing the big picture. In economic terms, this can be applied to bringing in different elements into an economic system, such as valuing the environment, society, and economic stability. Furthermore, all models suggest the importance of diversity and the human dimension (Build Resilience Through Diversity, Nurture Human Nature, Use And Value Diversity), offering a potential solution for coping with scarcity by building resilience through diversity.

7. Holistic Model for Future Generations

There is a lack of a fully holistic economic model that takes into account all of the three pillars of sustainability and is aligned with the core of economics in that it should consider society and human behaviour in response to the scarcity of resources. This paper aims to demonstrate the potential of creating a holistic economic model that protects people and the planet by design through the combination of the CE, the DE, and Permaculture. Combining these models aims to offer a solution to the issues with the CE identified [15,17] by adding a social dimension, ensuring the economic model is aligned with the socially focused SDGs and is more sustainable for future generations. In addition, it supports the DE in businesses [22] by bringing in the importance of financial stability and economics from the CE. Finally, by integrating Permaculture, it gives an economic value to Permaculture that can be used to guide businesses towards truly sustainable development by focusing on society, the environment, and economics. The additional principles of Permaculture [35] also offer a more holistic model that not only keeps society and the environment at the center but also offers a clearer guide on how to ensure people and the planet are considered.

Integrating these models can support the understanding of how companies can effectively ensure the three pillars of sustainability are met, and combining these models aims to offer a solution to the following questions:

- How can social dimensions from sustainable development concepts be integrated into the CE to create a holistic model that covers the three pillars of sustainability?
- How can an effective social and environmental dimension be built into a future economic framework?

Combining the CE: DE, and Permaculture suggests the potential of a future, holistic economic model for future generations.

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Eating, Community, Culture and Language: A Green Garden Approach †

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Abstract: Community green gardens in urban areas provide cultural anchors as well as fresh, inexpensive food for many city dwellers. Furthermore, green gardens offer an opportunity to educate young people about health, the environment, sustainable practices and animal lives. Unquestionably, more city and public resources should be allocated for expanding a network of city green gardens, especially in both private and public schools.

Keywords: urban farming; community gardens; gender; education; schoolyard gardens; veganism

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1. Introduction

This paper explores the growth and benefits of community green gardens in three boroughs of New York City: Manhattan, the Bronx and Brooklyn. The urban green garden movement emerged in New York City in the 1970s due to the failure of the food manufacturing industry to provide quality food in disadvantaged urban neighborhoods, where fast food chains abound, and fruit/vegetable stores and supermarkets are hard to find.

2. Eating, Community, Culture and Language: A Green Garden Approach

To sustain a healthy diet that also satisfies cultural norms and eating styles, communities impacted by economic, cultural, health and social issues rely mainly on green produce. A crisis engages people in dialogues to find solutions and to survive. New York City residents have faced hardships, food scarcity and limited food affordability, and found solutions in green garden projects. Green space is less accessible to urbanized cities, causing health and wellbeing concerns (Ferguson, et al. 2018) [1]. Nevertheless, community green gardens help solve the problems affecting disadvantaged communities. Community green gardens are "smaller plots of land usually integrated in the fabric of neighborhoods grown collectively" (Tharrey, et al. 2020) [2]. For small forms of food production, community green gardens are popular and their benefits are significant. For example, they have made it possible to feed the population; promoted the development of an urban culture favorable to agriculture; eliminated the abandoned spaces which in the past were breeding grounds for rodents and diseases; and provided positive social interactions for residents in the area (Companioni et al. 2002) [3]. In effect, green gardens have become sanctuaries for poor communities in New York City.

While many are independent or just community oriented, most community green gardens in New York City are educational settings and work in partnership with local schools. New York City has over 1000 green garden projects in its boroughs with many participants. A new green garden initiative is the Dyckman Farmhouse/Garden Kitchen Lab (DFH/GKL). In January 2021, the Dyckman Farmhouse partnered with the Garden

Kitchen Lab and opened a new garden in the Dyckman Farmhouse Museum, located in Manhattan's Upper West Side, and which focuses on children's education.

The DFH/GKL educates children about agriculture, culture and sciences. Children learn about the importance of green gardens and the eating habits of people from different cultures, as well as how to protect the environment and produce sustainable crops. They also learn "skills to start and sustain a food producing garden, while demonstrating the links between food production, the environment and their health" [4]. The DFH/GKL program differs from traditional community green gardens in its approach and definition as a "backyard-to-table, science-based, hands-on educational experience," as revealed in an interview with Fabiola Caceres, educational director of the DFH/GKL. It is an intergenerational, cross-cultural educational model that combines urban agriculture, culinary and STEM disciplines. It proposes to engage children and their communities to practice healthy food consumption and production. The program's curriculum is based on children and educators' feedback on their experience in activities in subjects such as anthropology, biology and culture. These activities introduce children to nature from scientific perspectives. Children learn by experience and formulate their own conclusions freely. Learning about cultural food consumption, healthy eating, composting, harvesting and planting make children resilient against unhealthy diets and eating habits.

Population growth challenges the economic and social structure of urban cities. The New York City population of 8,230,290 residents (as of 2021) has experienced the destruction of the infrastructure of its working-class neighborhoods—in housing, business, workplaces and green spaces. Ironically, these are the neighborhoods where low income and immigrant residents find affordable housing. Housing costs are unaffordable based on the salary of many residents, forcing them to sacrifice quality food for rent. The constant flow of people to large cities is making the problem worse. By 2050 it is estimated that perhaps up to nearly seventy percent of the population will reside in urban cities (U.N. 2014) [5]. Population increase in cities requires employment, food and green spaces for the inhabitants. Major industrialized cities are divided by socio-economic and racial factors, and it is not unfamiliar that those living in low income and racialized areas are more adversely affected by the lack of green space and nutritious food. Clearly, there are socio-economic and racial disparities about what is accessible to minority populations. As a result, New York City has augmented education programs about the creation of, participation in and benefits of community green gardens. Studies demonstrate the mental and health benefits of community green garden participants (McEachan, et al. 2016) [6]. A recent study suggests that the full health benefits of green garden participation happen over time and in the long run. This goal must be supplemented with other practices or activities, such as school nutrition courses, cooking classes, planting, harvesting instructions and eating habits and practices (Tharrey, et al. 2020).

The reality of economic and social factors in poor communities press residents to think about alternatives for self-sufficiency and sustainable production, maintain their communities, lift the morale of the residents, and develop an economy that creates job opportunities (Yi 2019) [7]. This is a strong approach for cities, whose residents "were less likely to feel invested in food production, conceive of opportunities for participation, or imagine spatial alternatives to the traditional farm" (Lamb 2014) [8].

Community green gardens are associated with women. Certainly, many community green gardens are created and maintained by women. Gender is important in the conception and participation in green gardens. The misconception that "gardens" are for women has caused bias against women and stereotypical discourse: women to the garden and men to the market. Community green gardens are not agricultural market activities that most men seek. Men disassociate themselves from green gardens because there are no financial benefits. In conversation with green garden managers, one noted the low participation of men in the creation and maintenance of markets. Since community green gardens relate to domestic consumption and production, men are less interested in participating. The study JArDins compared male and female gardeners against non-gardeners. It found that

the majority participants were female, held a university degree and had no experience in gardening (Tharrey, et al. 2020) but felt productive for having participated in the green garden. Gender influences participation in green gardens, but "ethnicity, class, age often play important roles in shaping specific patterns of participation" (Wooten 2003) [9]. Fabiola Caceres compared the participation of boys and girls in the program. While girls tend to outnumber boys, boys look at the financial possibility of becoming chefs. This male behavior is the consequence of the misconception that gardens are for women to embellish and for men to conduct business, confirming the stereotype. Changing the discourse about the green gardens as a profitable financial enterprise will change the stereotype.

3. Eating, Education, and the Language of Veganism

Cultural evolution, evident in urban green gardens from Section 2, can stimulate plant-based food ecology. In biology, organisms have relations to each other in their surroundings. This is true too for humans who manipulate, sometimes grossly, ecosystems to farm meat, seafood and dairy products. Our current ecology of food is mostly detrimental to our physical health, the earth's climate and animal lives. Physical and global wellness can be achieved through education and awareness efforts geared toward a vegan culture. Our australopithecine ancestral relatives were, as our extant cousin great apes are now, essentially vegetarians eating and surviving well on mostly fruits, leaves, nuts and seeds. Relying less on technology and more on informative shifts in attitudes, values and beliefs, we can effect positive change in our ecology of food. Advances in climate and agricultural technology should follow, not lead, an ecologically friendly mindset.

While this is not a blueprint, imagine a schoolyard garden in nearly every urban school where the vegetables are processed in the cafeteria kitchen as vegan products. Promoting the ethic and language of veganism could be a revolutionary shift in how we teach young people about food, health, the environment and animal lives. Melded into veganism are substantive issues about climate change. One study says that even among animal products, those of the lowest impact on terrestrial and aquatic ecosystems far exceed vegan substitutes (Poore & Nemecek 2018) [10]. Much of this necessary change depends on the language about health and nutrition. Children do not need to think of meat, seafood and dairy as essential foods when they are really not so for most people in many industrialized nations.

Why would we widely establish schoolyard gardens? To what extent are infrastructure and social changes required in our food ecology, and where do individuals fit into this new mindset? How is veganism a sustainable solution, not a passing digression, and is it feasible in educational or local communities? Suffice it to say that many healthy vegans (including vegan athletes) demonstrate that one can thrive without meat, seafood or dairy. Many existing meat-rendering establishments, with the proper private investment and government subsidies, could shift to manufacturing vegan products. Cultural evolution would be the prime driver of a vegan economy, employing education, social media and celebrity endorsements.

If there is a schoolyard garden, presumably with a kitchen in the school, or a community garden, perhaps with a kitchen in a nearby church or community center, vegan foods could be prepared. Vegan stir fry, patties, fritters, tacos, loafs, salads or wraps are easy to make. Young people can gravitate away from junk food to become self-sufficient. Later, the national economy might catch the spirit of positive change. Here is an example. Organizations like Grow NYC and Earth Matter support community gardening. That which was originally established as a teaching garden a few years ago on Governors Island, between lower Manhattan and Brooklyn, was converted into a fresh food supply source during the 2020 pandemic. Given the infrastructure on that island, which was once a military operations base, kitchens could prepare vegan foods from the abundance of vegetables and fruits grown there. Imagine the social benefits of a community garden and kitchen operated by local entities governed by minorities and women provided with city, state or federal grants. Then, magnify that model across a city, state, country or the globe with other decommissioned public institutions large enough to accommodate plant

gardens and kitchens. Think how all of the malls across the industrialized world that have been decommissioned could be converted to indoor veggie and fruit farms, where former restaurants could be established as vegan kitchens. With the right funding, much of this food could be donated to shelters or given to needy families.

Most of the bad effects of meat and dairy are happening on a local level anyway. Factory farms will not shut down overnight but could be phased out and repurposed. Many agricultural creatures need not be born into a life of cruelty where their confinement and bloody persecution contribute to ecological degradation. Vegan agriculture uses far less land than animal farming, is environmentally optimal and can feed more people in a nutritional manner with far less energy loss and waste (Shepon 2018; Eshel 2019) [11,12]. In 2006, the United Nations Food and Agricultural Organization released a report indicating that eighteen percent of greenhouse gas emissions comes from industrial animal agriculture, noting a "community danger" (Bristow & Fitzgerald 2011) [13]. That percentage is more than pollutants from worldwide transportation. By 2010, global greenhouse gas emissions from agriculture, forestry and other land use jumped to twenty-four percent (Edenhofer, et al. 2014) [14]. The Böll Foundation (2014) [15] says meat and dairy farming is responsible for upwards of thirty-four percent of global heating through direct and indirect fouling emissions. Environmental researchers Matthew Hayek and Scot Miller (2021) [16] say greenhouse gas emissions from concentrated animal farming in the U.S. have been underestimated and therefore compromise sustainability projections, taking into account expected increases in global meat consumption. The U.N. Food and Agricultural Organization estimates of emissions from animal agriculture are out of date, ecologically inefficient and should be revised upward (Twine 2021) [17].

The primary audience for veganism is mainly young people, since their future is at stake. Wangari Maathai (2006) [18], a Nobel Peace Prize recipient and creator of the Green Belt Movement, talks about how school gardens in her country of Kenya helped wean students off unhealthy fast foods. Industrialized countries have an obligation to help developing nations secure a stable plant food system that does not destroy local farms or ecosystems. Mainstream media hardly reports on vegan issues if at all, and television news rarely covers factory farming or the dairy industry unless it is about "the economy." Listening to and communicating directly with the language of non-vegans to foster "intergroup contact" is essential in overcoming bias (Pettigrew, et al. 2006) [19]. Crucial issues of good health and an uncontaminated environment should always transcend religious or political ideologies.

Animals do not need to be human food. Human consumption of animal products, whether flesh or dairy, equates to unnecessary cruelty and death. Animals are not fictional objects but subjects of a life (Regan 2004) [20], who value being alive, making it clear why some escape the slaughterhouse in an instinct for self-preservation (Colling 2020) [21]. Cows, much like sheep, pigs, etc., are peaceful; and so imagine the terror of any poor creature who can see and hear the bloody wails of death coming from others. While this does not need to be an ethical argument, a good illustration of that would be John Hill's *The Case for Vegetarianism* (1996) [22]. Many of his points are still, regrettably, valid. Some readers will present counter claims that any argument for veganism is too difficult to achieve, personally or economically. First, it is easy to transition from meat and dairy to whole foods and vegan products, if done properly and gradually. Second, there is a cultural opportunity in veganism to invest in local, urban vegetable farming and the manufacture of minimally processed vegan foods. Like other authors, Hill covers the bad consequences of livestock production, needless animal cruelty, poor health, pollution and world hunger. We need to concentrate on the prevention of disease and the mitigation of global warming and not simply on diagnoses, pharmaceutical treatments, and short-term corrections. Unavoidably, there are moral questions and ethical dilemmas in these concerns. For instance, see a book called *The Moral Complexities of Eating Meat* (2016) [23]. Are there "moral complexities" about meat, seafood and dairy agriculture or is it just wrong and unhealthy?

Philosopher Lucy Schultz (2020) [24] points out how, traditionally, nature has been set off in contrast to culture. There was a time when we were part of nature; then, with the formation of cities, human culture separated from and eventually, with industrialization, invaded nature. At the same time, Schultz goes on, humans are biological animals derived from and evolved through nature. Where is nature? We have fabricated possessions from nature, but to whose advantage? Western art and philosophy created a false idea of "nature" as wildlife, a landscape, another world, etc. This flawed dichotomy, like the erroneous separation of mind and body promulgated by the seventeenth century philosopher Descartes, has enabled humans to justify their abuse of animals and ecosystems. Pivoting to a community-based vegan economy with local gardens through education is a viable starting point to mitigate health and climate ills and to promote an animal-friendly ethos.

4. Conclusions

New York City green garden activists challenge the "traditional farm" concept by appropriating empty, abandoned lots, residents' private gardens and backyards to open green gardens for the community. This is a popular venue for people to engage in and experience the benefits of green gardens to "raise environmental awareness and encourage the adoption of more sustainable dietary practices" (Tharrey, et al. 2020). The movement is particularly ripe for educating the next generation of ecologically-minded and health-conscious citizens. The aforementioned benefits of community green gardens aid city residents to overcome the environmental and urban difficulties they encounter. To participate in a community green garden is an intercultural experience that alleviates hunger and transforms people's conception of agriculture, nature, eating, culture and community.

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GERD, a Path, or Hindrance toward SDG 6.5 in the Nile River Basin? †

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Abstract: This paper explores the possibility of achieving SDG 6.5 by 2030 in the Nile Basin by exploring the hydro-politics between the three main riparian states, Egypt, Ethiopia, and Sudan. Through a literature review of relevant sources, it is ascertained that, historically, Egypt has maintained a hegemonic control of the Nile through disputed treaties negotiated by Great Britain. However, the state-financed construction of the Grand Ethiopian Renaissance Dam (GERD) has the potential to shift this hegemonic control of the Nile Basin in favour of Ethiopia. While this construction may act as a source of political tension and low-scale conflict in the region, this paper critically examines how the implementation of a sustainable dam filling rate, Integrated Water Resource Management (IWRM), and the Nile Basin Initiative (NBI) can foster transboundary water cooperation between the three major players. In line with previous research, we argue that the GERD's main effect is mostly positive, especially if the three main riparian states are actively cooperating and are considering advice from the scientific community.

Keywords: Nile River Basin; Grand Ethiopian Resistance Dam (GERD); Integrated Water Resource Management (IWRM); Ethiopia; Sudan; Egypt; Sustainable Development Goal 6.5; water; Helsinki Rule

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1. Introduction

The River Nile is one of the world's longest rivers, running from the great lakes of East Africa to the drainage basin of the Mediterranean Sea. The importance of the Nile in the region cannot be overestimated, as it runs through 11 countries, covering almost 7000 km, while providing fresh water to approximately 400 million people. It is for this reason that the Nile has become almost synonymous with transboundary water conflicts in an area that is characterized by poor rainfall, intense droughts, and increased risks from climate change [1]. Economic development and rapid population growth in upstream countries have also augmented their demand for energy and arable land, increasing the pressure on the Nile, changing its natural flow rate and pattern [2]. It is for this reason that this paper will present a case study of the largest development on the Nile in recorded history, the self-financed Grand Ethiopian Renaissance Dam (GERD). This hydroelectric dam, with a technical capacity of 6000 MW, is located on the Blue Nile, which is responsible for 85% of the Nile River's overall flow and volume. Through this case study and an exploration of the existing and proposed water laws and treaties in the area, the goal of this paper will be to ascertain whether GERD will act as a source of cooperation between the three main riparian states or whether construction will exacerbate tensions and lead to the emergence of a "water war" in the drought-prone region. While early signs point towards cooperation within the basin, based on a 2015 agreement, it is still overshadowed by a fundamental conflict between upstream riparian states insisting on their right to develop their water resources. This development could significantly impact downstream river flows,

especially in Egypt, which strives to maintain current downstream flows and its historical hegemony over the Nile River. The paper will start with a description of the Nile Basin and challenges within the area and proceed to a study of the potential of Integrated Water Resource Management (IWRM) and the GERD dam to abate conflict in the area.

2. Study Area Description and Challenges in the Nile River Basin

The Nile is formed by two tributaries, the White Nile and the Blue Nile, and flows through 11 riparian states, namely, Egypt, Sudan, South Sudan, Eritrea, Ethiopia, Uganda, Kenya, Tanzania, Burundi, Rwanda, and the Democratic Republic of Congo (DRC), with a length of approximately 7000 km (Figure 1) [1]. The White Nile originates in the Great Lakes region of Central Africa, snaking through Tanzania, Uganda, and South Sudan. The Blue Nile on the other hand originates in the highlands of Ethiopia and flows downstream into South Sudan and Sudan from the southeast [3]. The two rivers meet near the Sudanese capital of Khartoum, where they form a confluence. The flow of the river then continues through the Sudanese desert to the Egyptian delta. Even though the White Nile flows for a longer distance (3700 km) than the Blue Nile (1450 km), it is the Blue Nile that provides the Nile River with approximately 85% of its flow and volume [3]. The source of the Blue Nile is the highly variable monsoon-driven rain from the Ethiopian highlands. Historical rainfall data show that Ethiopia has a much lower dependence on the Nile for water than the other riparian states as they experience approximately 2032 mm of rain per year in some areas. On the other hand, Egypt and Sudan only get about 10 mm of rainfall per annum, making them high-risk drought areas [4]. The challenge is compounded by the rapid rise of the population of the basin countries; over the period 1960 to 2010, the population of the basin countries grew fourfold, thereby resulting in declining per capita water availability [4]. This increased level of irrigation causes riparian states to draw more water than their internal renewable resources can sustain [3], thus highlighting how the Nile Basin is fast becoming one of the global hotspots in the quest for the food, energy, and security that water provides [1]. The flow rate of the Nile compared to other major rivers is also very interesting to consider. In relative terms, the Nile does not transport much water: approximately 84 km^3/year when compared to the Amazon River's 5518 km^3/year and the Congo River's 1250 km^3/year, which are of similar lengths [3]. This can be directly attributed to low amounts of rainfall and a high evaporation rate in the region. The tributary on the border between Ethiopia and Sudan is of particular importance because it is where the GERD Dam has been constructed, placing Sudan at the centre of the hydro-political tensions between Ethiopia and Egypt (Figure 1) [4]. Construction of this USD 5 billion dam began in 2011 and is set to be completed in 2023 [5]. When completed, the dam will have an energy generation capacity of 6.45 gigawatts, making it the largest hydroelectric power plant in Africa and one of the biggest in the world. The structure of the dam is made up of the main dam, a high rock saddle dam, a reservoir, and three spillways [6]. This design was suggested by the International Panel of Experts (IPoE) as the most efficient, equitable, and cost-effective way of generating hydroelectricity for Ethiopia without harming water access for downstream countries [7].

Figure 1. Map of the Nile River Basin that flows from the upstream southern states (Uganda, Ethiopia, and South Sudan) toward the downstream northern states (Sudan and Egypt) [8].

3. GERD: Hindrance or Facilitator of SDG 6.5

3.1. Benefits of the GERD to Ethiopia

The construction of GERD could act as a counter-hegemonic play for Ethiopia to gain political control of the Nile [1]. While this newfound control by damming the Blue Nile provides Ethiopia with an avenue to improve its hydropower generation, it presents threats to the food and energy security of the other downstream riparian states [6,9]. Ethiopia was able to self-finance this dam through an increasing GDP growth rate of 10.9% per annum from 2004–2014, making it the fastest-growing economy in the world during this period [10]. This growth has allowed Ethiopia to embark on an ambitious infrastructural development scheme which includes but is not limited to a new railway to Djibouti, East Africa's first light rail system, and the construction of Africa's largest airport and hydroelectric dam [11]. The GERD dam is probably the most significant of these projects politically and economically. Not only does it shift hegemonic control in the region in

favour of Ethiopia, but it also provides basin countries with the opportunity to meet their growing energy needs. Ethiopia, in particular, will have the opportunity to satisfy the power and energy demands of 234 million people [12]. To put this into perspective, Ethiopia has a population of 109 million, meaning that Ethiopia can become a net exporter of energy, earning approximately USD 1 billion per annum from energy sales. This also allows the opportunity to improve energy access for its citizens, who use only 66.199 kw of energy per capita, which is amongst the lowest energy usage rates in the world [2], thereby inducing a double-sided multiplier effect which will improve the quality of life and economic growth in the country. From an agricultural point of view, the Rocky Mountain Institute shows that electrifying small rural farms will also lead to USD 4 billion of potential economic opportunity [13]. On the other hand, the official Egyptian stance on the GERD dam is very clear. The authorities are against any developments of the Nile that will disrupt water flow into the region and are willing to use military force to ensure that their hegemonic control of Nile resources continues. Climate change, low rainfall, and increasing population [3] have made Egypt's need to control the Nile even more imperative, as research shows that Egypt has begun to use more water than their internal resources can produce and faces heightened water insecurity in the future [14], especially in high-drought years [15,16]. The underlying cause of this increased water consumption is the population explosion within the last 30 years. It is estimated that Egypt's population has almost doubled from 45 million people to 80 million people (90% of whom live along the Nile Basin) within this period. This has, in turn, led to an indiscriminate and unsustainable drawing of water resources for irrigation to provide food and energy in the region [16].

3.2. Impact of the GERD on the Riparian States

This section of the paper will deal with the more technical aspects of filling the dam. It will study the effects of the three filling rate scenarios that have been presented by Ethiopia and negotiated with Egypt and Sudan. For SDG 6.5 to be achieved and a water war avoided, in the region there needs to be an agreement on the filling rate that is employed to fill the reservoir of the Ethiopian Dam. Progress has already been made towards this with a dispute resolution mechanism ratified by Egypt, Ethiopia, and Sudan in 2015; however, conflicts remain over the rate of filling of the reservoir of the GERD dam [16]. Egypt prefers that the reservoir be filled as slowly as possible, preferably over 10 years, while Ethiopia wants to engage in filling as fast as possible over a much shorter period. If managed in the correct manner, shifting water supply (storage) from the Egyptian desert to the Ethiopian Highlands may in fact increase Egypt's water supply over time [17], since Ethiopia has a much lower average temperature than Egypt, which implies that the evaporation rate of water will be slower in the Ethiopian reservoir than the reservoir in the Aswan Dam. However, this also allows Sudan to use the dam as a source of irrigation, which will have permanent and detrimental implications for Egypt [9].

A study found that with limited cooperation between Ethiopia and Sudan on the management of the GERD in the long term, the Blue Nile flow would still be steady enough to allow significant irrigation expansion [18]. The overall gain to Sudan's agriculture sector from executing the proposed irrigation schemes throughout 2020–60 was discovered to be approximately USD 13.5 billion depending on the cropping pattern [18]. The type of cropping pattern is crucial to expanding economic benefits [18]. The GERD is responsible for Sudan's expected GDP increase, anywhere from USD 48–82 billion depending on whether there is a collaboration between Sudan and Ethiopia and the type of cropping pattern implemented [18]. The Egyptian basin evaporation loss is likely to decline by 9.922%. However, the influx of water is going to decrease by 2.755% because of the effect GERD has on the High Aswan Dam [19]. Although the GERD is set to reduce energy production by the High Aswan Dam by 5.243%, it is expected to increase energy production capacity by 15,000 GWh for the eastern part of the Nile basin [19]. Since this energy is sold for a much cheaper price in Egypt, the energy loss should not present a significant issue.

The GERD benefits Ethiopia and partly Sudan during the impounding phase; however, it has economic costs to Egypt, particularly when Egypt is in a series of dry years [15]. The adverse consequences of the GERD on Egypt's economy are overturned when the GERD is operating [15]. Research suggests that Egypt is inefficient in terms of irrigation and general use of the Nile water as a resource [20]. Studies have shown that Egypt can greatly benefit from the implementation of the GERD if they adapt to it by making retrofits and if they cooperate with Ethiopia [15,20]. Firstly, Egypt can halt the use of plants that consume a lot of water such as rice so that they can save one billion cubic meters (BCM) of water yearly [21]. By replacing rice with other agricultural plant species that are economically beneficial and that use significantly less water, Egypt can prepare its country against drought periods during the filling of the GERD. Egypt can also upgrade its irrigation system by transforming miniature field canals from the surface canal to pipes, which can save 42% of water loss from leakage and evaporation [22]. This retrofit would save Egypt around 7.4 BCM per year [15]. A study also found that both Egypt and Sudan would benefit from an increase in profit in the agricultural and energy sector by USD 4.9–5.6 billion due to the GERD, which provides additional flow [23]. Elsayed (2020) has demonstrated that depending on the fill rate, Egypt would lose 9–19% of its food production and 3–9% of its hydropower production during the impounding phase of the GERD [6]. In contrast, during the GERD's operation, food production is to be 4% reduced, whereas hydropower generation is to be 7% reduced [6]. For Sudan, the hydropower generation may decrease by 2–29% during the impounding phase, whereas the irrigation supply reliability may decrease by 50% [6]. Sudan is mainly to benefit from the operation of the GERD, which is set to increase their hydropower generation by 6% as well as improve their irrigation supply and reliability [6].

3.3. Impact of the GERD on Achieving SDG 6.5 in the Nile Basin

In the short term, the GERD is unlikely to help achieve SDG 6.5 in the Nile Basin. This is because Egypt argues that its water availability from the Nile River Basin will decrease and, currently, they still sit in the unknown, without any experience of the extent of the effect that the GERD will have on its country. In general, people tend to feel losses more deeply than gains of similar magnitude [24]. Thus, if Egypt does not feel like they are gaining enough from the GERD, it will continue to oppose the GERD. Moreover, since Egypt's influx of water is going to decrease, they will feel this loss more acutely considering that, in general, people feel water losses more deeply than almost any other commodity [25]. This feeling of water loss may become more acute during the dry season, which could subsequently translate into an evolving tension with Ethiopia and water panic between irrigators and civil society, which could be exacerbated with social media [26]. However, in the long-term, the GERD is more likely to achieve SDG 6.5 due to more cooperation and discussion between the riparian states, mainly Egypt, Ethiopia, and Sudan. Egypt will also come to realize that the water losses are not significant enough for a continuation of opposition to the GERD. Meanwhile, Ethiopia is optimistic with regards to the effect of the GERD in the long run and is anticipating a mutually beneficial result for the Nile riparian states. Although Egypt might be concerned about the low levels of water in their HAD reservoir, they are likely to become less anxious sooner or later [26]. A study demonstrated that the GERD could be constructed without significantly affecting the water supply and the irrigated agriculture of Egypt [27]. As the year goes by, with the GERD implemented, Egypt should come to realize that its impact is insignificant and that it can benefit through cooperation, changing its crop species, and retrofitting its water supply system. This can happen through discussions between the three states and if Egypt takes on the advice from scientists with regard to its crops.

The rhetoric by the Egyptians has also not helped the push towards achieving SDG 6.5 in the Nile River Basin. The former Egyptian president, Muhammad Morsi, once threatened military action against Ethiopia due to the GERD project [28]. At first, Egypt declared an official rejection and then contemplated sabotaging the dam, followed by future contribution to trilateral discussions and agreements, demonstrating acceptance of

the GERD, which shows that Egypt was originally ill-equipped to deal with this project, especially when they were preoccupied with internal political and economic alteration [28]. Sudan, on the other hand, showed support for the GERD and downplayed its negative effects while applauding the advantages of the GERD, such as its capacity to regulate flows and its ability to expand irrigated agriculture by the Sudanese Blue Nile [28]. Sudan plays an important role in relation to achieving SDG 6.5 in the Nile River by taking a mediating role between the two states and presented its intention to achieve mutually beneficial agreement between the three states and suggested implementing the International Panel of Experts' (IPoE) recommendations [28]. The IPoE was composed of two experts from Sudan, Egypt, and Ethiopia, and four neutral international experts [7]. It was initiated to evaluate Ethiopian studies on the GERD, assess whether it is aligned with international standards, and determine its effect on downstream countries [7]. The IPoE gave recommendations to Ethiopia with regard to implementing engineering studies on the height of the dam and its capacity and safety [7]. Ethiopia's goal was always to implement the dam in a way that would benefit all the riparian states. Ethiopia claims that it is not part of the 1959 Treaty and is permitted to an "equitable share" if there is no significant harm to downriver states [29].

4. Challenges and Opportunities for IWRM in the Nile

4.1. SDG and IWRM Goals

The Sustainable Development Goal 6 focuses on "ensuring availability and sustainable management of water and sanitation for all" [30] (p. 11). This SDG Target 6.5 aims to "implement integrated water resources management at all levels, including through transboundary cooperation as appropriate by 2030" [31]. Indicator 6.5.1 monitors the degree of integrated water resource management implementation as a percentage [31] with respect to four components: enabling environment, institutions and participation, management instruments, and financing as a way to monitor the progress toward the implementation of IWRM [31]. By building on this theme, the Global Water Partnership defines IWRM as "a process which promotes the coordinated development and management of water, land and related resources, to maximize the resultant economic and social welfare equitably without compromising the sustainability of vital ecosystems" [32]. IWRM is a broad framework in which decision makers can decide the goals of water management and implement the use of various mechanisms to accomplish them [33]. IWRM is an extensive, ongoing process that should be tailored to unique, different situations [34]. Therefore, the goals of IWRM vary across countries and various weights are set on the importance of economic, environmental, and social impacts [33]. In this section of the essay, we reflect on the potential for achieving SDG 6.5 in the Nile Basin through the construction of the GERD as well as whether it helps or hinders progress toward SDG 6 in the Nile Basin.

Our preliminary findings are that the three major states, Egypt, Sudan, and Ethiopia, must cooperate and implement rules and regulations in line with IWRM so that SDG 6.5.1 can be achieved in the Nile River Basin by 2030. We also find that the other riparian states must also be involved and informed of the changes that are being made to the Nile River with regard to GERD and other projects to foster holistic cooperation. Wheeler et al. (2016) showed that management and cooperation between these three major states should include an agreement on a yearly release from the GERD, a drought policy for the High Aswan Dam (HAD), and a precautionary discharge from the GERD if the HAD water level drops under a vital level [35]. This ensures that Egypt's needs are achievable with the collaborative management of the upstream infrastructure in Ethiopia and Sudan [35].

4.2. Existing Laws and Frameworks

One of the challenges that hinders the way toward achieving the SDG 6.5 is the long-standing international law between Egypt and Sudan, that is, the 1959 treaty. The first Nile River Agreement between Great Britain (Sudan) and Egypt was signed on 7 May 1929. This treaty was meant to bind Sudan to receiving Egypt's approval before any irrigation plans and also gave Egypt the right to use Victoria Lake and other water bodies around the Nile

River [36]. The treaty specifically asserts: "Egypt has a claim to the entire timely flow at an amount of 48 billion cubic meters per year; Egypt has a right to on-site inspections at the Sennar dam; Egypt is guaranteed that no projects would be developed along the river or on any part of its territory, which would threaten Egyptian interest" [36] (p. 17). The arrangement for sharing the Nile River water was revised in the 1959 treaty between Sudan and Egypt [36]. The treaty states that both countries can fully utilize the Nile water and that Egypt was allowed to use 55.5 billion cubic meters of water per year, which allowed them to construct the Aswan Dam, while Sudan was granted 18.5 billion cubic meters [37]. This agreement did not include any other riparian countries of the Nile (including Ethiopia), which means that they did not have water allocated [36]. More than 60 years later, the 1959 treaty still has not ended the conflict arising from water usage and is still highly contested by upstream states. These issues led four countries (Ethiopia, Rwanda, Uganda, and Tanzania) to sign the Cooperative Framework Agreement (CFA) in 2010. The main disparity between the CFA and the 1959 treaties is that instead of specifically quantifying the amount of water allocated to a country, the CFA encourages a framework to stimulate integrated management, sustainable development, mutual use, and conservation of the water so that it benefits every riparian state equally in the present and long-term [38].

4.3. International Legal Instruments

Another water law that differs significantly from these early agreements on the Nile and offers some hope for guiding riparian states in a mutually beneficial direction is the Helsinki rule. The Helsinki Rules applies to groundwater connected to surface water and the use of water in an international drainage basin [39]. The Helsinki rules, which were issued in 1966, marked the first time that transboundary groundwater was addressed by any international legal instrument [39]. Although these rules had no legally binding effects, they remained the most widely quoted set of rules for regulating the use and protection of international watercourses until the United Nations Convention 30 years later [39]. One of the Helsinki Rules states that "consistent with the principle of equitable utilization of the waters of an international drainage basin, a State: (a) must prevent any new form of water pollution or any increase in the degree of existing water pollution in an international drainage basin which would cause substantial injury in the territory of a co-basin State, and (b) should take all reasonable measures to abate existing water pollution in an international drainage basin to such an extent that no substantial damage is caused in the territory of a co-basin State" [40]. This rule implies that a state must abate water pollution, which is a threat to the health of its people. In the context of the GERD, Ethiopia has to ensure that during the construction of the dam no significant amount of pollution is added to the River at the expense of another state's access to an adequate amount of clean water. The two aspects of the Helsinki Rules that are the most well-known are the cardinal principle of the equality of all the riparian states in the utilization of the watercourse and the factors for ascertaining equitable and reasonable use [39]. The Helsinki Rules are the legal foundation for the use of international basin water and have been included in the UN Convention and the Berlin Rules [39].

The UN Watercourses Convention (UNWC), formally titled 'The United Nations Convention on the Law of Non-navigational Uses of International Watercourses', is another framework of rules that must be followed to ensure cooperation between the Nile Basin riparian states. This comprehensive convention is divided into seven parts and contains 37 articles. Importantly, it states that "an international watercourse shall be used and developed by watercourse States to attain optimal and sustainable utilization thereof and benefits therefrom, consider the interests of the watercourse States concerned, consistent with adequate protection of the watercourse" [41]. The legalities related to IWRM are important to understand when implementing projects along the Nile River so that no international legal instruments are neglected and so that everyone can benefit from its implementation. However, previous studies show that the seven factors considered in Article 6 of the UNWC lack measurability, which can elicit doubts about its applicability

and interpretation [42]. Egypt has quoted the 'no harm' rule as it argues for equitable and reasonable utilisation of the river while also invoking the prior notification rule as a means to inspire the international community to compel Ethiopia into pausing or halting the construction of the GERD [1]. This tactic was successful in previous years and Eldardiry and Hossain (2021) show that Ethiopia was not able to receive funding from the World Bank and the African Development Bank for its water development project due to Egypt's opposition [43]. However, the arrival of China as a superpower in Africa altered the situation in Ethiopia's favor owing to Chinese firms' interest in assisting Ethiopia to utilize its hydropower [43].

These aforementioned treaties, laws, and conventions ultimately resulted in the Declaration of Principles signed on 23 March 2015 between the three main states associated with the GERD and contains 10 principles. The first principle states that mutually beneficial cooperation aligned with international laws is necessary so that upstream and downstream states' water needs are met [44]. The subsequent principle declares that the three main countries must prevent significant damage being done to the Blue/Main Nile, that downstream states must gain priority access to the energy created by the GERD, and that interpretational conflict should be resolved through consultations or negotiations [44].

4.4. Nile Basin Initiative and Cooperative Framework Agreement

To achieve a shared vision of sustainable socio-economic development through the equitable utilization of the common Nile Basin water resources between riparian states, the Nile Basin Initiative (NBI) was launched in 1999. The NBI established a comprehensive cooperative program whereby riparian states may work collectively on large-scale projects, including numerous investment developments that could create socio-economic benefits for all states in the long term [28]. All the 11 riparian states that the Nile flows through initially signed up as part of this coalition apart from Eretria, which maintains observer status [11]. The initial goal of the NBI was supposed to act as a temporary stopgap till the region could set up a Cooperative Framework Agreement (CFA) to act as a permanent agreement between the riparian states. It was expected that this CFA agreement would double as an inclusive legal and institutional framework to govern the hydro-politics of the region and ensure a more equitable distribution of Nile resources. However, the negotiation of the CFA has come to a serious impasse. The CFA encourages a framework to stimulate integrated management, sustainable development, mutual use, and conservation of the water so that it benefits every riparian state equally in the present and long-term, rather than allocating specific quantifies of water to a country [38]. This is in direct contrast to the 1959 treaty ratified between Egypt and Sudan.

This impasse led to four countries (Ethiopia, Rwanda, Uganda, and Tanzania) signing the Cooperative Framework Agreement (CFA) in 2010, to the dismay of Egypt and Sudan [28]. Sudan and Egypt reacted by ending their involvement in all NBI undertakings and projects [28] in June of 2010. Sudan eventually returned to the NBI in November of 2012 after realizing that basin-wide cooperation is essential, especially after the GERD project was launched in 2011 [28]. Sudan's response to the GERD was positive and improved the NBI, indicating that the GERD inadvertently gave positive attention to the NBI and the inevitability of basin-wide cooperation (so that everyone can benefit from shared use of the Nile River) [16,28]. Thus, the GERD constitutes an opportunity to improve states' national interests by benefiting from its energy production (Ethiopia vowed to sell hydropower to Egypt and Sudan at a cheaper price), sustainable usage of water, and socio-economic advantages [28,43]. Nevertheless, the CFA has been questioned by Egypt and is yet to be approved by an adequate number of Nile Basin states to come into operation [18].

In terms of the current responsibilities in the region, the Nile Basin Initiative operates three main programs to improve water cooperation in the basin. These include the Shared Vision Program, the Eastern Nile Subsidiary Action Program, and the Nile Equatorial Lakes Subsidiary Action Program [4]. The Shared Vision Program is a basin-wide program that focuses on building institutions, sharing data, information, and training, essentially creating

avenues for dialogue and region-wide networks needed for joint problem-solving. The Eastern Nile Subsidiary Action Program is managed by the Eastern Nile Technical Regional Office in Ethiopia and seeks to develop the Eastern Nile Basin sustainably for more equitable distribution of resources in that specific geographic zone. The last program that is supported by the NBI is the Nile Equatorial Lakes Subsidiary Action Program which focuses on reducing poverty, promoting economic growth, and reversing environmental degradation. Funding for the NBI is sourced from the World Bank, the Global Environmental Facility, and the African Development Bank. These funds are augmented by contributions from the NBI member countries. The governments of the United States, Switzerland, and the European Union are also stakeholders within the NBI, acting as conflict resolution facilitators rather than main funders of the initiative [11].

5. Conclusions

In conclusion, this paper has improved our understanding of the official positions of Egypt and Ethiopia regarding the GERD. Through research the reasoning behind Egypt's decision to previously oppose the GERD project and Ethiopia's motivation to build the GERD have become more apparent. The exploration of the existing laws and international legal instruments has also managed to highlight the benefits/drawbacks of the GERD based on scientific research and has allowed us further to ascertain how the GERD will create a path toward SDG 6.5 in the Nile River Basin. The result shows that the GERD can be perceived as a great opportunity for achieving SDG 6.5, provided that there is continued cooperation between the three main riparian states. Through hyper-hybrid coordination between Ethiopia, Egypt, and Sudan, Egypt should be able to improve its water use efficiency, Ethiopia its energy generation, and Sudan its access to irrigation [20]. This hyper-hybrid coordination is meant to create the most effective coordination between Egypt, Ethiopia, and Sudan by suggesting that they collaborate to strengthen regional integration through resource management, reconciliation and security, investments, trade, and informative programs [20]. Current rainfall trends also forecast that drought is an unavoidable eventuality [4] in the future, further highlighting the need for a thorough basin-wide management plan agreed on by the three main riparian states. This plan must and should contain a management policy for the GERD [26] that will reduce the impacts of droughts in the region. These plans should indicate how the decreased flow of the Nile will be distributed when storage is drained in both reservoirs and will require balanced power generation and usage [26]. Although Egypt continues to oppose the rate of filling of the reservoir, researchers suggest that this reaction is normal in the short-term and that in the long-term acceptance of the GERD is more likely to result, since Egypt should continue to have an adequate amount of water as a resource according to the scientific literature [15,20,25,27].

The NBI also plays an important role in achieving SDG 6.5 by creating permanent mutually beneficial agreements between all riparian states. The increased attention that the NBI has received during/after the construction of the GERD has prompted Sudan to return to this platform in 2012 [28]. However, this framework cannot be successful without the return of Egypt, meaning that it is not working as effectively as it could. For now, it seems more likely that these hydro-political issues will be resolved through IWRM over time, especially when Egypt, Sudan, and Ethiopia start to cooperate actively with each other through the declaration of principles signed in 2015. This agreement raises the likelihood of reconciliation in the future through the NBI and eventually the establishment of the CFA as more scientific research and discussions of the positive externalities of the GERD in relation to Sudan and Egypt continue to be published.

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Proceeding Paper

Building Layout Influence on Occupant's Energy Consumption Behaviour: An Agent-Based Modeling Approach †

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Abstract: Building energy consumption is affected by several factors, including its physical characteristics, indoor/outdoor environment, and appliances. However, the occupant's behaviour that governs and controls the building's energy consumption must not be forgotten. In most of the earlier studies, occupant behaviour is modelled as static or fixed occupancy profiles. These profiles are acknowledged as the main source of discrepancy between the predicted and actual building energy performance. Several studies have been performed to identify the occupant's sustainable energy behaviours related to social, climate, economic, regulations, and personal aspects. However, building indoor configuration such as space-layout planning has various impacts on occupant sustainable energy consumption behaviour as indoor space layout might affect occupant's movement and presence. Furthermore, it may link to the occupant's particular activities or actions that happen at a specific position within an indoor space. So, this study used an Agent-Based Modeling (ABM) approach to understanding the influence of indoor layout configuration on occupant energy consumption behaviour in residential households in Chittagong, Bangladesh. The study has shown a considerable amount of building energy savings while using a sustainable space layout configuration. The simulated energy consumption data from the ABM model was further validated using the real data collected from the available smart meters in the case study location. Thus, the study will assist in recognizing the proper space layout arrangements with occupant choice and their behavioural intentions of residential building energy savings for low-income economies.

Keywords: building layout; occupant's behaviour; energy-consumption; agent-based modeling

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1. Introduction and Background

The residential and commercial building industry is an important opportunity for accelerating the transformation of energy-saving and ensuring a worldwide low-carbon future [1,2]. According to the IEA-EBC (International Energy Agency-Energy in Buildings and Communities) [3], the typical building energy performance might be influenced by six essential factors such as climatic condition, building envelope, interior design, building energy and service systems, building operation and maintenance, as well as occupant behaviour [4,5]. Reviewing the current findings on building energy conservation, one can recognize that, for the most parts of such studies focus on operational energy, comprising building energy and maintenance, as well as building service systems. Nevertheless, moving beyond the technological approaches studied by these findings to buildings analysis, variations in occupants' and energy consumption behaviour of occupants have recently been noticed to be a comparatively economical option for building energy saving. Occupant energy consumption behaviour is mostly well-defined as the occupants' actions towards

the building energy-related events, i.e., controls of appliances such as HVAC, lighting, windows, blinds, etc. [6,7]. However, it has been noticed that precise predictions of occupant behaviour have frequently been achieved because of its arising from the intrinsically different characteristics of individual occupants. Moreover, many researchers have also observed that there can be tremendous discrepancies between the inhabitant's or occupant's annual energy consumption, even for nearly identical buildings [8,9]. Nevertheless, this study focuses on energy saving from a different point of view by emphasizing occupant-oriented perspectives, based on the assessment of accounting for saving components that neglect the actual energy consumption of the building occupants [10]. In this regard, Occupant Centred Design (OCD) techniques (i.e., space layout deployment) may incorporate an investigation into how and why individuals' occupants use energy [11,12], and this knowledge can advise the plan about the proper interventions to improve energy conservation [13]. Moreover, occupant's space layout deployment is one of the design efforts between 'design development' and 'scheme design' in the initial design phase. It is a significant part of the building that affects the overall building energy consumption in the future. Furthermore, earlier studies have demonstrated that there is an incredible gap between the energy-saving potential and data availability to help the design in the early stage [14,15]. As one significant task in the early design stage, space layout is required to have great possibilities of energy saving. In addition, a small number of analyses have been approached to evaluate the impacts of indoor space layout on building energy consumption [11,16]. All studies have revealed that space layout can considerably influence building energy performance. Furthermore, the bigger part of these studies is the mixed space model with several aspects, for instance, occupant's operation and movement strategy [6], shading framework [17], and window to wall ratio [18]. It makes it problematic to evaluate the effect of space layout dependent on the existing research. It is fundamental to confine a space plan from different parameters to completely recognize its influence on the energy consumption of a building. Thus, this comprehensive study targets breaking down the unfinished effect of occupant space layout configuration on building energy conservation. Moreover, previous studies have made significant attempts for modeling building occupant behaviour by applying various methods [19]. One of the methodologies is the implementation of agent-based modeling (ABM), which could be considered for stochastic behaviour prediction from the individual to group-level occupants [20]. Typically, ABM is a simulation-based system that comprises multiple or single autonomous operators, called "agents", that interact with each other and their environmental condition in accordance with specific behaviour rules or laws. Similarly, the entire parts of an agent in ABM might be symbolized with the aim that the agents might think and act similar to human [13].

Thus, this study aims to introduce an Agent-Based Modeling (ABM) approach in the field of space layout deployment on occupant energy conservation behaviour. Here, building space layout is characterized as the interior collocation of various spaces, which incorporates the interior arrangements, the position of interior furniture, equipment, etc. [21]. Moreover, since most occupant-related investigations are designed on synthetic data and scenarios, therefore this study also tries to fill this gap by presenting a validation approach using real data obtained from the available smart meter in a residential building in Chittagong, Bangladesh.

This article is structured as follows; Section 2 describes the methodology of the study; Section 3 clarifies the results and discussions, including the validation approach, and Section 4 concludes the study.

2. Methodology

The research approach of the study has been divided into three phases: Phase I: predicting occupant behaviours and their action within the layout; Phase II: calculating the energy consumption using the ABM model and Phase III: validating the output with real data. Here, the ABM model is constructed using the AnyLogic modeling tool, which is a broadly established simulation platform, especially in the engineering, business, and sociology

domain. Figure 1 represents the basic components of the proposed study framework. In this framework, assigning behaviour, agent decision-making process, agent interactions, and learning addresses Phase I; layout deployment, energy interface, Revit, Dynamo_Excel platform and simulation outputs address Phase II, and the "Model Validation & Interpretation" address Phase III.

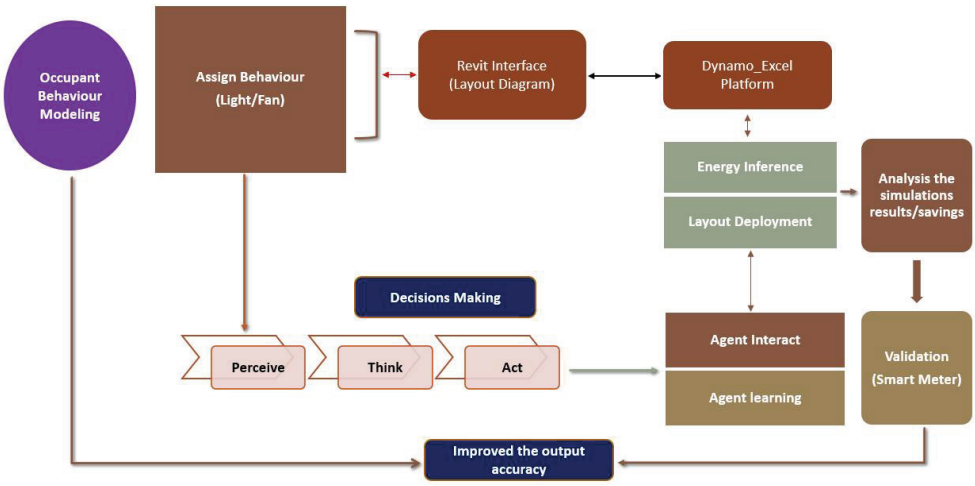

Figure 1. Whole research framework.

Usually, an occupant agent observes its surroundings, which is well-described by the input data and the space layout information as well as thermal and visual situations of the specified spaces. The layout conditions (Figure 2) correspond to the individual's agent's destination (e.g., seating point) and other parameters (e.g., switch distance) that allow an occupant agent to realize its motivation to keep track of the energy calculation. The goal of the energy estimation is to describe how agent (occupant) behaviours influence the interior of allocation within the space. This can expressively influence the occupant's destination; switch distances and environmental conditions that also consider the behavioural variations made by occupant agents. The last part of the framework is intervention and model validation, which determine the flexibility and robustness of the proposed model.

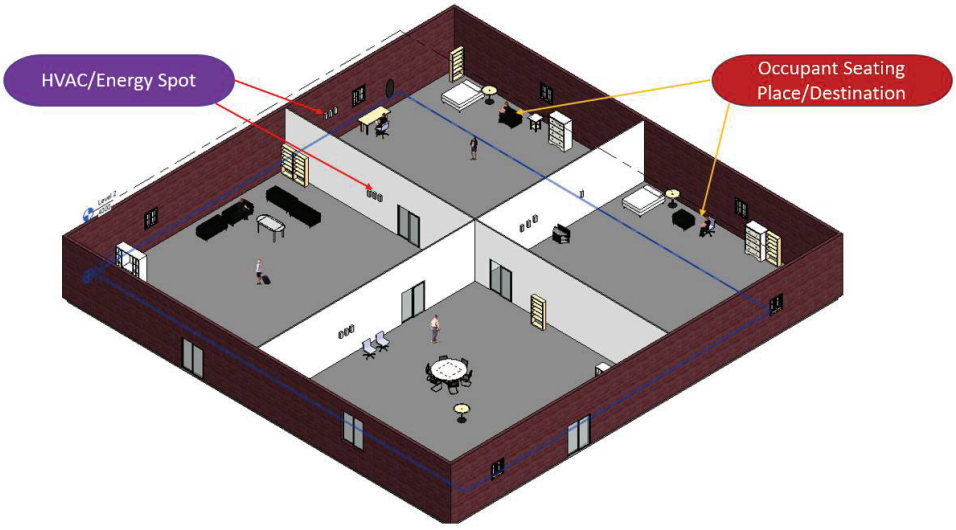

Figure 2. Occupant seating place and energy spot.

3. Results & Discussion

3.1. Model Output

Using the developed ABM model, several simulations were executed. The simulation outcomes were calculated in one-minute interval. The following figures (Figures 3 and 4) show the simulation outcomes for two individual rooms (similar size, dimension, and indoor allocation) of a residential building. This includes individual energy consumption patterns without and with intervention for a group of occupants. The simulated results indicate a considerable amount of building energy savings while using a sustainable space layout configuration. However, the energy consumption pattern and potential savings for similar rooms were different. It may connect to the occupant's number related to metabolic gains from the human body as well as indoor and outdoor environmental conditions [19]. In general, during the summer season, the outdoor solar radiation and temperature are above average, as well as heat gains from the building envelope are also high [19,22].

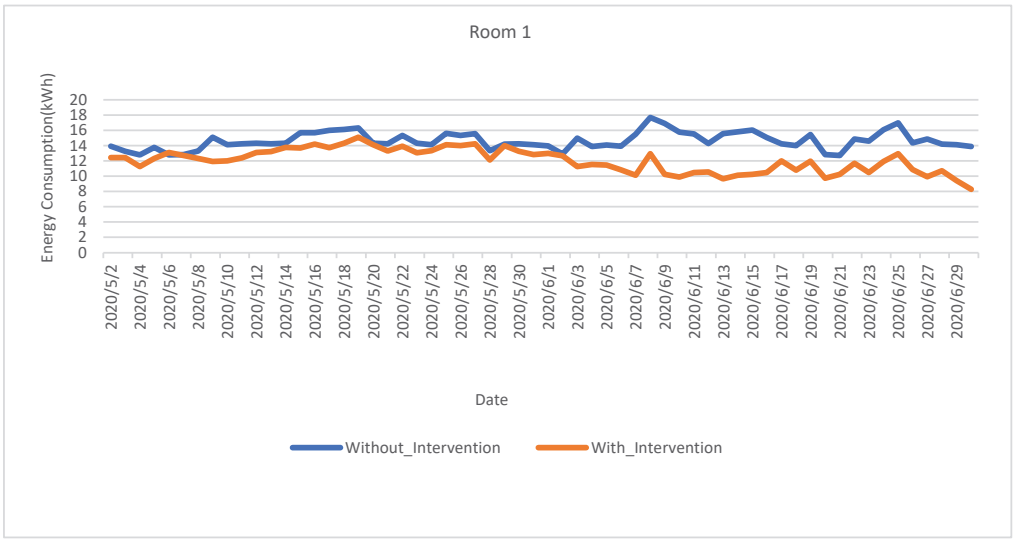

Figure 3. Simulated energy consumption profile for space layout 1 (Room 1).

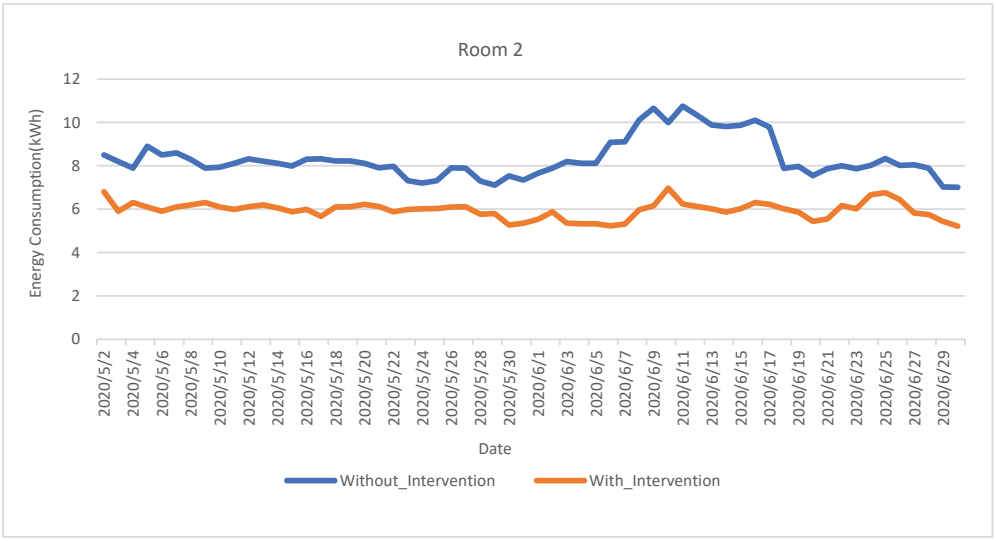

Figure 4. Simulated energy consumption profile for space layout 2 (Room 2).

3.2. Validation

Typically, a validation approach is required for the simulated model to check its robustness and feasibility. The purpose of this approach is to compare the energy consumption

data obtained from the real occupied building. Typically, real energy data are empirical, commonly called "true" data; it is recommended as a powerful validation tool because it can be manipulated to evaluate the reviewing data [23]. In this regard, simulated energy consumption data were further validated using the real data obtained from the smart meter (Figure 5).

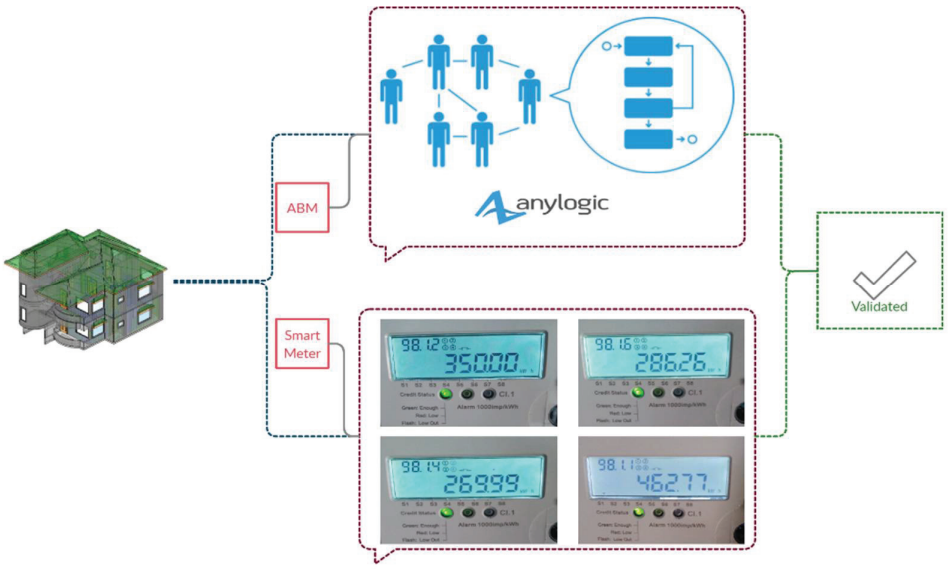

Figure 5. Model generated data validation approach using smart meter available in the case study location.

Herein, upon the prior consent from the inhabitants of the four apartments, the time interval for smart meter data collection was set to approximately 24 h, and these data were collected and written in a Microsoft Excel file. Figures 6 and 7 show the model and smart meter estimated (during intervention) monthly energy consumption data for the multi-family houses at XX Port Connecting Road, Chittagong. XX is a fictitious number as we do not want to disclose the address of the building for data security purposes.

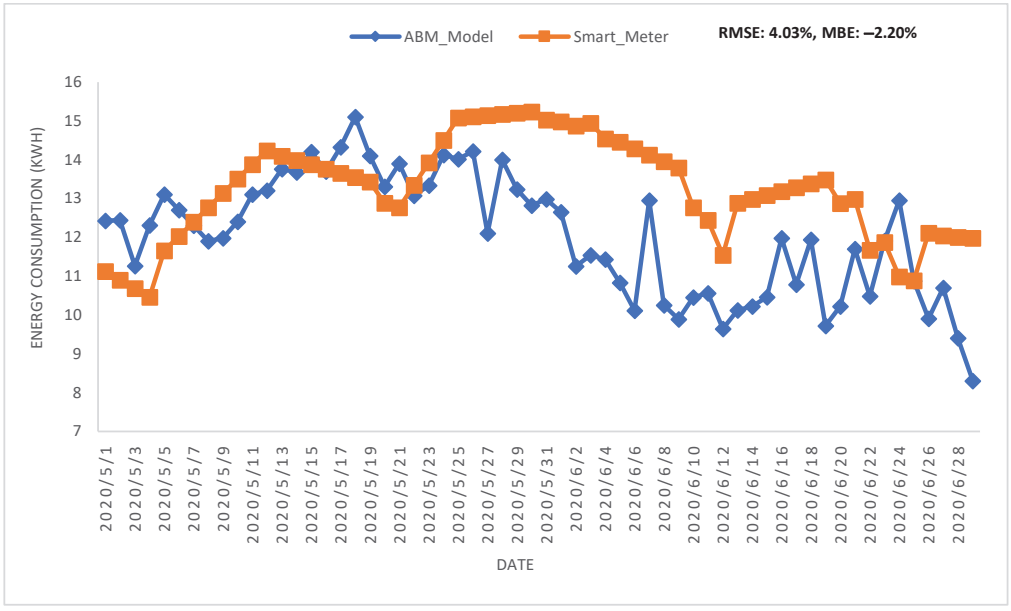

Figure 6. Model vs. Smart meter data for Room 1(RMSE: 4.03%, MBE: −2.20%).

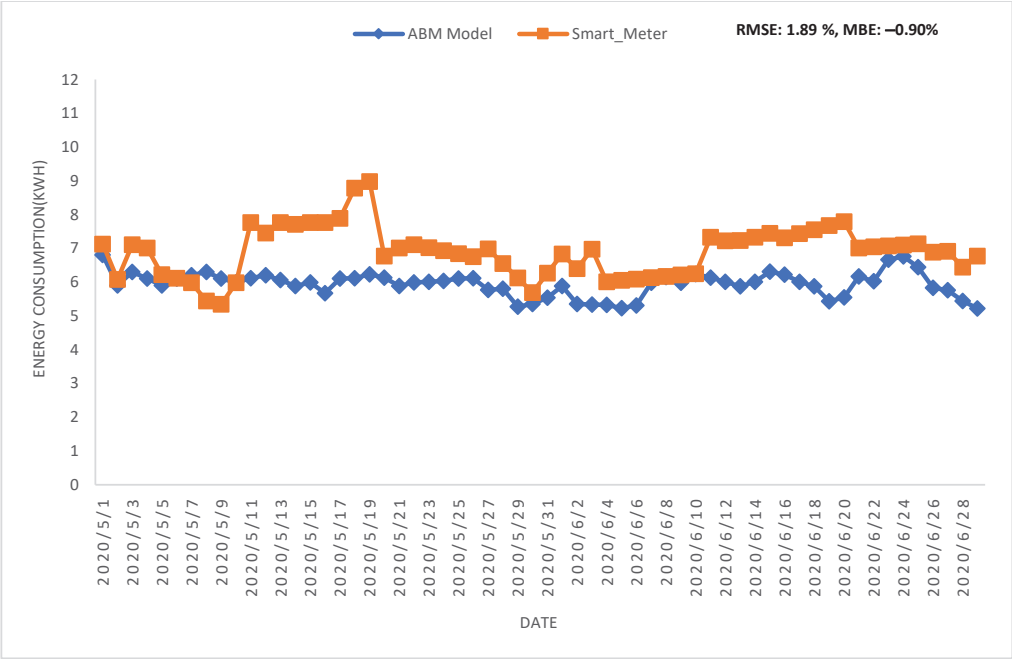

Figure 7. Model vs. Smart meter data for Room 2 (RMSE: 1.89%, MBE: −0.90%).

The data demonstrates that the simulated model slightly underestimated (i.e., negative MBE values) the occupant energy consumption for Room 1. On the other hand, there is a similar energy consumption pattern for both simulated and smart meter provided energy consumption profiles for Room 2.

Several reasons exist for the energy discrepancy between the model-generated output and real energy data. However, for data reliability checking, the American Society of Heating, Refrigerating and Air-Conditioning Engineers (ASHRAE) standard 14-2002 [24] and Federal Energy Management Program (FEMP) guidelines [25] were considered to check the data correction tolerance. It includes verifying two dimensionless errors, called Mean Bias Error (MBE) and Coefficient of Variation of Root Mean Square Error CV(RMSE). Normally, the standard correction tolerance of MBE and CV(RMSE) are ±10% and 30%, respectively. This study showed that in all cases, MBE and CV(RMSE) values lie within the acceptable range (e.g., for Room 1: RMSE: 4.03%, MBE: −2.20%; and Room 2: RMSE: 1.89%, MBE: −0.90%).

In summary, although there are substantial variations that appeared between the simulated and observed data, still the majority of the data fall within the standard tolerance limit specified by ASHRAE and FEMP guidelines. Indeed, occupant behaviour is tough to show due to the randomness and highly stochastic nature of residents. The study also revealed that it is essential to explore the general pattern of individuals' behaviour and integrate the data with an energy simulation model as well.

4. Conclusions

The study seeks the influence of occupant behaviour in building energy conservation in the context of indoor layout configuration using agent-based modeling (ABM). The study aim is satisfied with the implementation of the ABM approach to promote an energy-efficient building system and identify the key players through appropriate intervention. The study also offers a validation approach to improve the simulation reliability, trustworthiness as well as robustness of the model. Although there is a smaller amount of energy-saving prospects noticed due to applied intervention, however, both the simulation model and the experimental study revealed that layout re-configuration (i.e., intervention) plays a significant influence on occupant energy consumption profile.

It is mentioned that the study only considers a few space layouts (e.g., only two rooms) for data validation purposes, as extended data gathering cannot be possible due to the COVID-19 pandemic. A wide-ranging space layout selection and broader data collection, including further behavioural laws/rules, should be identified and incorporated into the framework for modeling more complex occupant comfort and behaviour in buildings. Moreover, comprehensive knowledge of occupant behaviour will assist in simulating an advanced energy prediction model which keeps direct cause and impact that would provide superior control algorithms and systems design. From a diverse point of view, one might also predict energy inadequacies due to occupant behaviour, permitting engineers and architects to improve occupant control at an early phase in the design.

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Data Availability Statement: Data are available on-demand from the corresponding author.

Conflicts of Interest: The authors declare no conflict of interest.

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environmental sciences proceedings

MDPI

Proceeding Paper

From Transparency to Impact: Findings from the Development of Australia's First Environmental Product Declaration and Carbon Neutral Ready-Mix Concrete †

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Abstract: Concrete contributes 8% of global greenhouse gas (GHG) emissions. The development of a concrete EPD is a critical "missing" piece to having all key infrastructure and building products represented by an EPD in Australia. The publication of the first EPD for ready-mix concrete in Australia has led to exciting new opportunities to improve the way low-carbon concrete is specified in tenders and contracts. With the ability to provide mix-specific third-party verified data, EPDs are leading the way for construction contractors and clients to send a clear signal of intent for embodied carbon reduction in the concrete supply chain.

Keywords: concrete; low carbon concrete; carbon neutral concrete; low embodied carbon concrete; Environmental Product Declaration

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1. Introduction

All around the world, the expectation for Governments and organisations to provide enhanced transparency and disclosure of environmental impacts, such as greenhouse gas (GHG) emissions, has been growing. This follows the landmark COP 21 Paris Agreement in 2015 in which all nations agreed to ambitiously pursue efforts to combat climate change and its effects [1].

To deliver the ambitions of the Paris Agreement and keep global average temperature rise well below 2 °C, all sectors of the economy must decarbonize [1]. Currently, buildings account for 39% of energy related global CO_2 emissions [2], demonstrating the importance of the building and construction sector in fulfilling these ambitions. Of this sector contribution, 28% comes from operational carbon, with 11% arising from the energy used to produce building and construction materials, usually referred to as embodied carbon [2].

At the same time, the global demand for construction materials is also growing due to worldwide population growth and an increase in urbanisation. As a key input into concrete, the most widely used construction material in the world, cement is a major contributor to climate change [3]. The chemical and thermal combustion processes involved in the production of cement are a large source of carbon dioxide (CO_2) emissions. Each year, more than 4 billion tonnes of cement are produced, accounting for around 8 per cent of global CO_2 emissions [3]. This clearly demonstrates both the essential need for construction materials now and in the future, as well as the necessity for the construction materials industry to be a leading part of the solution addressing climate change.

The first Environmental Product Declarations (EPDs) for ready-mix concrete in Australia (ViroDecs^{TM}) constituted a major investment in comprehensively analysing and communicating to customers the embodied environmental impacts of Holcim's ready-mix concrete.

The development of a concrete EPD is a critical "missing" piece to having all key infrastructure and building products represented by an EPD in Australia. Its publication supports designers and developers to drive improved sustainable procurement and materials selection.

Prior to the publication of the first EPDs for ready-mix concrete, sustainability professionals and procurement managers in the built environment sector were forced to rely on dated national average data for information on the Global Warming Potential (i.e., embodied carbon) of ready-mix concrete. This created a blurred picture for understanding the various embodied impacts of ready-mix concrete, affecting everything from the Infrastructure Sustainability (IS) Materials Calculator to whole-building Life Cycle Assessments under Green Star and carbon abatement strategies for organisations seeking Science Based Targets.

Not only affecting strategic and design work, the lack of company-specific (let alone mix-specific) data also constrained the built environment sector in the manner in which it specified and procured low-carbon concrete. Proxies such as Portland cement reduction and percentage of supplementary cementitious materials (SCM) used were widely adopted as a compromise position.

The publication of Australia's first EPD for ready-mix concrete has led to exciting new opportunities to improve the way low-carbon concrete is specified in tenders and contracts. With the ability to provide mix-specific third-party verified data, Holcim is leading the way for construction contractors and clients to send a clear signal of intent for embodied carbon reduction in the concrete supply chain.

2. Materials and Methods

Data collected from across Holcim's Australian operations, including over 190 concrete batching plant sites and 46 quarries was fed into an ISO14044-compliant Life Cycle Assessment (LCA) model by specialist practitioners to generate an Environmental Product Declaration (EPD) to ISO 14025 and EN 15804, which have been independently reviewed by an approved third-party verifier.

The primary data for the LCA are based on 2017 calendar year production data. SimaPro (v8.4) was used for the LCA modelling, using background data from:

1. The Australian National Life Cycle Inventory Database (AusLCI) (2017);
2. ecoinvent 3.4 (2017);
3. World Business Council for Sustainable Development (WBCSD) Cement Sustainability Initiative (CSI) Tool Project database (international version) (2018);
4. Product specific EPDs for admixtures and fibres.

Allocation was necessary to proportion inputs and outputs to intermediate flows at the quarry and processes at the batching plant level. As much as possible, intermediate flows were allocated physically based on weight (quarries) or based on m^3 of concrete (at the batching plant). At the quarry level, whenever physical allocation was not possible, economic allocation was carried out based on Holcim's internal cost system.

Regarding inputs, it was assumed that fly ash and silica fumes are waste products and therefore burden-free. Ground granulated blast furnace slag from steel blast furnace production was allocated economically. BS EN 16757:2017 specifically lists the following materials relevant to the study as co-products:

- Fly ash;
- Ground granulated blast furnace slag;
- Silica fume.

As such, the above materials are considered as coproducts of their production process, and the impacts for their production process are allocated according to PCR 2012:01 Construction Products and Construction Services (co-produced goods, multi-output allocation). Default background data from LCA databases were used to model the above co-products:

- Fly ash: the AusLCI process for fly ash treats it as a waste material and only includes transport impacts.
- Ground granulated blast furnace slag: the AusLCI process for slag is allocated based on economic value, as the product has significant economic value at the point of collection.
- Silica fume: the ecoinvent process for silica fume treats it as a waste material and only includes transport impacts.

The allocation approach of the AusLCI LCA database was adopted as a default for secondary data and processes (e.g., secondary fuel in cement production). The AusLCIdataset conforms to EN 15804 when applying allocation to its various processes and sub-processes. Data quality for the foreground data was assessed in terms of geographic and temporal representativeness is shown in Figure 1. All data sources were scored at medium or higher.

Module	Input/outputs	Sub-processes	Data source	Temporal scope	Geographic scope	Quality
A1	Coarse aggregate Manufactured sand Fine aggregate	Electricity	Electricity provider invoices	2017	All states	High
		Diesel	Supplier invoices	2017	All states	High
		Pollutants	National Pollution Inventory (NPI) data	2017	All states	High
		Mains water	Water utility invoices	2017	All states barring NSW	Medium
		Water – other sources (lakes, groundwater, rainwater)	Metered withdrawal data	2017	All states barring NSW	Medium
		Water discharge from site	Measured site data	2017	All states barring NSW	Medium
		Explosives (Manufactured sand and Coarse aggregate only)	Invoices	2017	All states (excluding the Kalgoorlie Quarry in WA which purchases raw feed from an external source)	High
		Gravel	Calculated – spoil + production amount	2017	All states	High
		Spoil	Holcim waste records	2017	All states	High
A2	Aggregate transport	Background data used to model	Actual transport distances and loads per trip	2017	All states (excluding Lynwood Quarry which transports by freight rail)	High
A3	Concrete batching plant	Electricity	Electricity provider invoices	2017	All states	High
		Diesel	Supplier invoices	2017	All states	High
		Mains water	Water metres, with utility invoices as a back-up	2017	All states	High
		Water – other sources (lakes, groundwater, rainwater)	Estimate based on water balance	2017	All states	Medium
		Water discharge from site	Estimate based on Holcim site performance metrics	2017	All states	Medium
		Lubricating oil	AusLCI concrete process	2015	National	Medium
		Conveyor belt				
	GP Cement Fly ash Slag Silica fume Admixtures Fibres	Background data used to model	Holcim internal technical database containing mix designs	2017	All states	High
	Packaging waste	Background data used to model	Estimate based on researched packaging material and sizes	N/A	N/A	Medium

Background data sources were also assessed with respect to their timeliness, with all data sources being last updated within the 10 years required under the PCR 2012:01.

Figure 1. EDP Data quality.

The processes included in the LCA are presented in a process diagram in Figure 2 below.

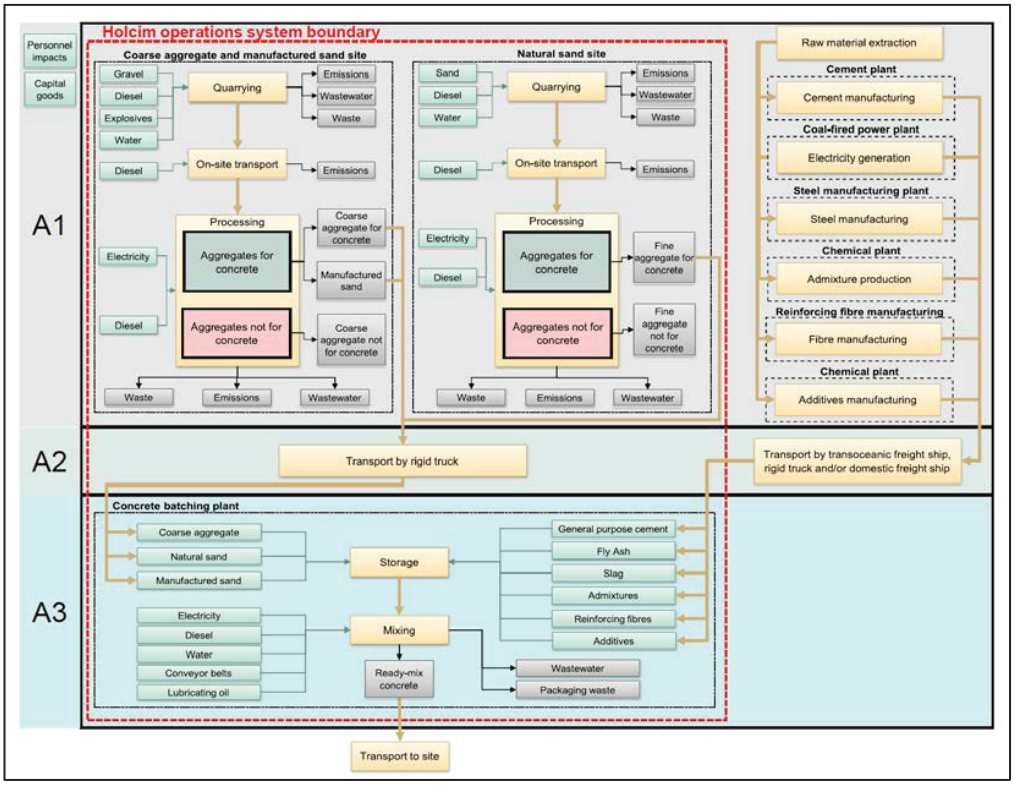

Figure 2. System diagram—the processes included in the EPD LCA in a process diagram.

The key assumptions and limitations of the EPD LCA are outlined and assessed in Figure 3.

Assumption or limitation	Potential impact on LCA results	Discussion	Adjusted impact on LCA results
Raw material data for most of the materials in concrete production is based on generic information.	Significant	The EN 15804 standard permits generic data for upstream processes, however, this is where the main impacts are for products across the life cycle.	Medium
Transport distances assumed for all raw materials barring quarry products	Medium	Conservative assumptions regarding transport distance were made based on country of origin and transport mode information.	Low
It was assumed that all concrete mixes require or result in an equal amount of site resources or discharges.	Medium	The uncertainty analysis undertaken to understand the potential likely impact of this assumption on the LCA results demonstrates that it has a minimal impact on most impact categories.	Low
National average values for site resource use and discharge (quarries and concrete batching plants)	Significant	The uncertainty analysis undertaken to understand the potential likely impact of this assumption on the LCA results demonstrates that it has a minimal impact on most impact categories.	Low
Tolling plants are assumed to have a similar site resource use profile as Holcim operated concrete batching plants.	Low	Concrete batching plant resource use constitute less than 1% of environmental impact in each impact category. Tolling plants (i.e. third part plants toll manufacturing for Holcim) have the same site resource use profile as Holcim branded sites.	Low

Figure 3. The key assumptions and limitations of the EPD LCA.

3. Results

The Holcim's normal-class concrete products included in this EPD have been grouped according to a set of key properties outlined in Figure 4.

Property	Explanation	Application in product grouping
Strength	Concrete strength is measured in units of pressure (MPa) and refer to the load bearing properties of the material.	There are 5 normal-class strength categories in the EPD: 20, 25, 32, 40 and 50 MPa
Blend	The blend refers to the type and number of supplementary cementitious materials (SCMs) included in the mix design.	The 4 normal-class blend categories in the EPD: G - general mix (no SCM) F - fly ash included B - ground granulated blast furnace slag included T - triple blend (includes slag & fly ash)
Slump	A measure of the consistency of fresh concrete, based on the measured reduction in mm of the height of a pile of concrete, as recorded via the 'slump test' method.	A single slump category (80mm) was adopted as an overarching parameter for the normal-class mixes included in the EPD. Please note: the WA-50-B product group consists of mixes at 120 slump
Cement content range	The amount of general purpose cement in 1 m^3 of concrete	Each normal-class product group in the EPD has a defined cement content range for which the EPD results are considered 'representative' (as defined in Section 2.5 of the PCR 2012:01).

Figure 4. Ready-mix concrete key grouping properties for EPD.

The global warming potential (GWP) environmental impacts (unit kg CO_2 equivalents (GWP100)) for 1 m^3 of Holcim ViroDecs™ normal-class ready-mix in New South Wales (NSW) and the Australian Capital Territory (ACT) are shown in Figure 5.

PRIMARY INDICATORS			GWP
Strength (MPa)	Blend	Cement content (kg/m3)	kg CO_2 eq
20	G	245–280	273
	F	180–224	220
	B	118–145	171
	T	100–123	152
25	G	255–315	297
	F	200–249	241
	B	130–159	185
	T	106–124	154
32	G	298–355	343
	F	227–285	273
	B	138–170	196
	T	122–147	176
40	G	380–430	405
	F	279–347	328
	B	177–216	243
	T	156–189	219
50	G	500–515	514
	F	371–436	414
	B	233–285	303
	T	241–255	284

Figure 5. Cradle to gate GHG emissions (kg CO_2-eq) for 1 m^3 of ViroDecs™ normal-class ready-mix concrete in NSW and ACT. Blend categories: G—General Portland cement mix (no SCM), F—fly ash included, B—ground granulated blast furnace slag included, T—triple blend (includes slag & fly ash). Results presented for medium mix designs using data from 2017. Cement content ranges are provided to assist customers in identifying whether the concrete purchased is covered by the ViroDecs™ EPD. Purchased concrete with a lower or higher cement content is not covered by the ViroDecs™ EPD.

It was found that Holcim's normal-class ready-mix concrete has a range of greenhouse gas (GHG) emissions across each different states, strengths, and blend, covered by the EPD (Figure 6). The GHG emissions associated with 1 m^3 of Holcim normal-class ready-mix concrete in New South Wales (NSW) and the Australia Capital Territory (ACT) Australia are shown in Figure 6 for:

- Holcim ViroDecs™—General Portland Cement;
- Holcim ViroDecs™—Fly Ash Blend;
- Holcim ViroDecs™—Blast Slag Blend;
- Holcim ViroDecs™—Triple Blend.

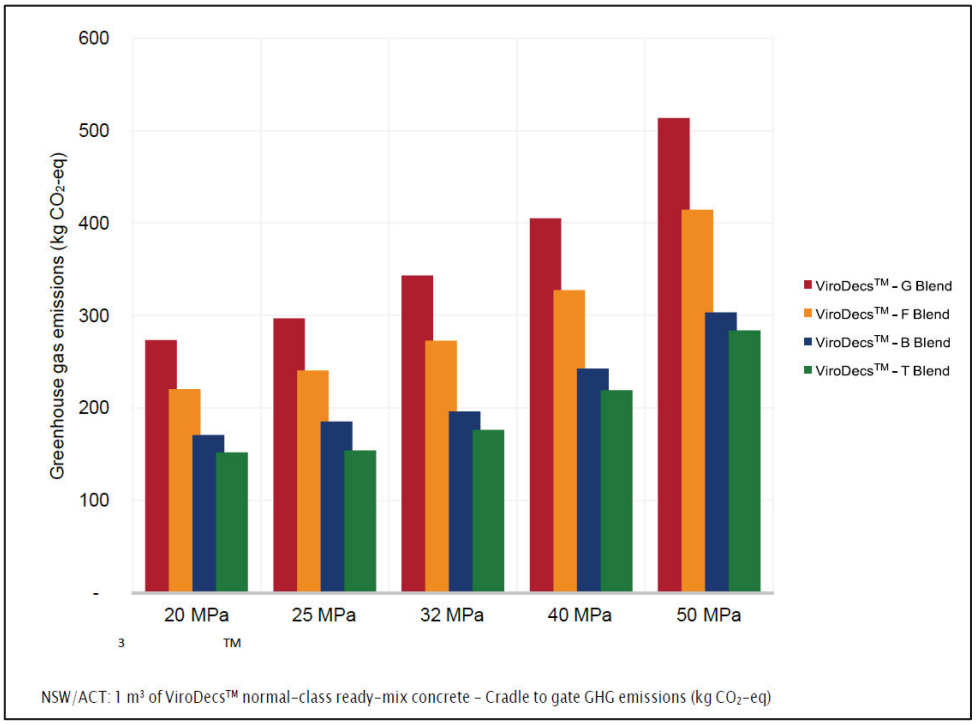

Figure 6. Cradle to gate GHG emissions (kg CO_2-eq) for 1 m^3 of ViroDecs™ normal-class ready-mix concrete in NSW and ACT. Blend categories: G—General Portland cement mix (no SCM), F—fly ash included, B—ground granulated blast furnace slag included, T—triple blend (includes slag & fly ash).

4. Discussion

To evaluate the performance of Holcim's ViroDecs™ normal-class ready-mix concrete range, the EPD results were benchmarked against the Green Star concrete reference case, IS materials calculator default concrete mix, and the Australian National Life Cycle Inventory Database (AusLCI). The following figure shows the results (Figure 7).

The modelling showed that in comparison to the Australian National Life Cycle Inventory Database's (AusLCI) general ready-mix concrete with no cement substitution:

- Holcim's ViroDecs™ General had up to 28% less CO_2-equivalent than the Australian average;
- Holcim's ViroDecs™ Fly Ash Blend had up to 42% less CO_2-equivalent than the Australian average;
- Holcim's ViroDecs™ Slag Blend had up to 52% less CO_2-equivalent than the Australian average;
- Holcim's ViroDecs™ Triple Blend had up to 57% less CO_2-equivalent than the Australian average.

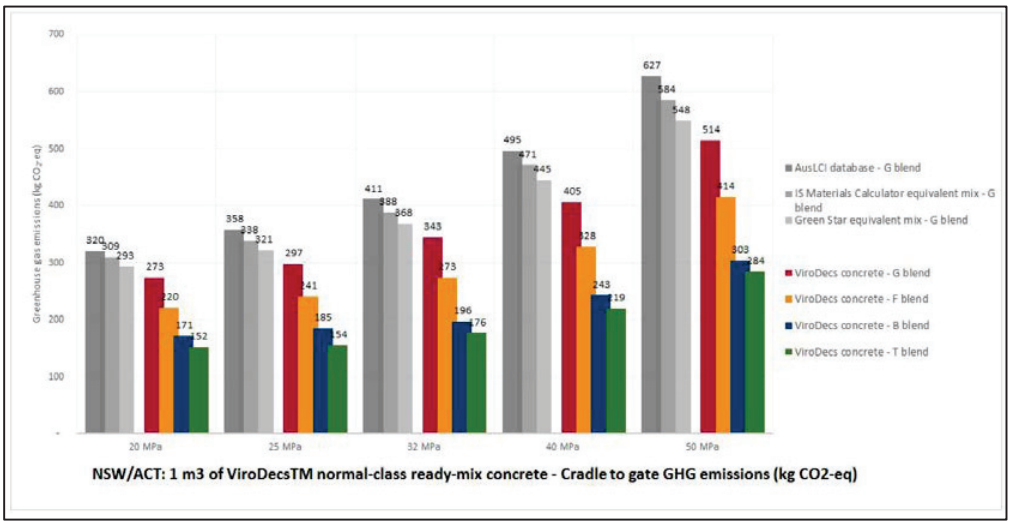

Figure 7. Cradle to gate GHG emissions (kg CO_2-eq) for 1 m^3 of ViroDecsTM normal-class ready-mix concrete in NSW and ACT benchmarked against the Green Star concrete reference case, IS materials calculator default concrete mix, and the Australian National Life Cycle Inventory Database (AusLCI).

Highlighting the potential benefits of the lower carbon concrete with a 57% reduction in embodied carbon, on a hypothetical 500,000 m^3 large scale infrastructure project, using 50 MPa ready-mix concrete instead of the equivalent normal-class concrete could reduce greenhouse gas emissions by up to 170,000 tonnes of CO_2-equivalent. This is a GHG emissions reduction equivalent to removing 32,635 cars from Australian roads (based on 0.401 kg CO_2-eq per km of car travel (AusLCI) and an average travel distance 13,400 km per car in FY17/18 (ABS: https://www.abs.gov.au/ausstats/abs@.nsf/mf/9208.0 (accessed on 4 December 2019))) or powering 24,285 Australian homes with renewable energy sources (based on an average greenhouse gas impact of seven tonnes CO_2-eq for an Australian household per year from energy use (http://www.yourhome.gov.au/energy) (accessed on 4 December 2019)) for a year.

In March 2020, in another Australian-first for Holcim and the construction industry, Holcim used the EPD to gain certification from Australian Government's National Carbon Offset Program 'Climate Active' to sell certified carbon neutral ready-mix concrete. Climate Active is a program administered by the Australian Federal Government to support businesses committed to sustainability, innovation, and industry leadership to drive voluntary climate action. The Climate Active certification enables Holcim to offset the remaining embodied carbon of its ready-mix concrete products on behalf of its customers on an opt-in basis through a transparent third party assured process, which ultimately results in carbon neutral ready-mix concrete (Holcim's ViroDecs Zero).

For a large infrastructure project in Australia (500,000 m^3), the difference between using Holcim's ViroDecs Zero Carbon Neural ready-mix concrete and the Australian average for general blend concrete with no cement substitution could be as much as 313,000 tonnes of CO_2e. This is the same as taking over 58,000 Australian cars (based on 0.401 kg CO_2-eq per km of car travel (AusLCI) and an average travel distance 13,400 km per car in FY17/18 (ABS: https://www.abs.gov.au/ausstats/abs@.nsf/mf/9208.0) (accessed on 4 December 2019)) off the road for a year.

It is noted that in addition to reducing carbon emissions, the offset projects also have the potential to bring additional benefits, including environmental (e.g., habitat and biodiversity protection), economic (e.g., income from the sale of offset units and employment to manage the project), and social (e.g., capacity building and health improvements in local communities).

5. Conclusions

In 2019, Holcim Australia set out to shake up the concrete industry by publishing the first ready-mix concrete Environmental Product Declaration (EPD) in the Australian market. Prior to the publication of the first EPD for ready-mix concrete in Australia, sustainability professionals and procurement managers in the built environment sector were forced to rely on dated national average data for information on the Global Warming Potential (i.e., embodied carbon) of ready-mix concrete. This created a blurred picture for understanding the various embodied impacts of ready-mix concrete, affecting everything from the Infrastructure Sustainability (IS) Materials Calculator to whole-building Life Cycle Assessments under Green Star and carbon abatement strategies for organisations seeking Science Based Targets.

Not only affecting strategic and design work, the lack of company-specific (let alone mix-specific) data also constrained the built environment sector in the manner in which it specified and procured low-carbon concrete. Proxies such as Portland cement reduction and supplementary cementitious materials (SCM) fractions were widely adopted as a compromise position.

The publication of the first EPD for ready-mix concrete in Australia has led to exciting new opportunities to improve the way low-carbon concrete is specified in tenders and contracts. With the ability to provide mix-specific third-party verified data, EPDs are leading the way for construction contractors and clients to send a clear signal of intent for embodied carbon reduction in the concrete supply chain.

Using EPDs as a building block, concrete can be specified in terms of global warming potential (measured in kg CO_2-eq). This opens up the opportunity for suppliers to promote their low embodied carbon products, creating healthy competition that benefits projects and the economy, as well as the environment.

The publication of EPDs for a number of construction materials in Australia highlights the importance and benefits of a standardised evidence-based approach to environmental claims and the evaluation and selection of materials based on their true sustainability performance.

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Proceeding Paper

Setting the Direction for a Sustainable Future? A Critical Review of University-Enterprise Partnership Evaluation †

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Abstract: University–enterprise partnerships foster great opportunities for sustainable development by enabling the translation of research into viable commercial solutions. However, how do we measure the relative "success" of such a partnership? This paper critically considers traditional evaluation methodologies to identify relative merits and shortfalls. Common themes include measuring against predominantly economic criteria and an over-reliance on global metrics at the expense of capturing regional impact. Potential consequences include undervaluation of local impact, disproportionate prioritization of economic impact, and the subsequent sidelining of environmental benefits. A place-based evaluative approach is proposed for future research to alleviate shortfalls.

Keywords: evaluation; place-based; university-business collaboration; co-creation; third-mission; sustainability

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1. Introduction

This paper recognises the importance of university-business collaboration (UBC) in fostering sustainable outcomes and specifically aims to shed light on a crucial yet frequently overlooked element of UBC: evaluation. Evaluation, when completed successfully, provides an opportunity for growth, reflection and strategic planning [1]. It captures issues and achievements that may otherwise have been overlooked and allows for proactive action to maximise the potential for sustainable development.

Looking to university-business collaboration (UBC) for sustainability ideas and projects is by no means a new concept. Its utility for sustainable development has been widely cited throughout the literature [2–4]. This has been echoed within the public sector, with the formation of the European University-Business Forum [5] and special mention within the United Nations Sustainable Development Goals [6]. Despite this, relatively little attention has been given to critical evaluation of UBC. Although the opportunities are significant for accelerating sustainable entrepreneurship, it is important to consider structural, cultural and social disparities which may act as barriers to enabling successful innovation.

One common critique of studies of social systems is that the target systems are often analysed in isolation of their external environment; as Cresswell [7] puts it, "the fish don't talk about the water (p. 263)". Through greater consideration of the place in which social phenomena are situated, there is reason to suggest that social elements shaped by place may be highlighted and shown in a new perspective [8]. In addition, such thinking may offer unique opportunities for questions of sustainability: through analysing how place influences social interactions, the manners in which social interactions shape place are equally highlighted [9].

Given the centrality of place in discussions of sustainability, this paper uses the lens of place to critically explore the ways we evaluate UBC for sustainability. Through

a systematic review of the literature, the paper identifies three different approaches to evaluation across the literature, and points to the shortcomings of these approaches to evaluation. In order to overcome these challenges, the paper recommends a place-centred approach to evaluation which captures the often-overlooked elements of UBC: local impact, existing power relations and the less tangible social relations frequently neglected in reductionist evaluative approaches.

2. Materials and Methods

To investigate current practice relating to UBC evaluative research, a comprehensive systematic literature review was undertaken. This was the chosen methodology due to its demonstrable ability to reduce the risk of bias within the literary study, providing a robust and replicable means of study and representing a thorough coverage of the chosen area [10]. In particular, systematic reviews have been shown to add great value specifically to the field of university-business collaboration however significant efforts are required to ensure that the methodology is fit for purpose and used in an effective manner [11]. Following this guidance, clear research questions were identified:

1. How are university-business collaboration projects for sustainability currently being evaluated?
2. How is place considered within university-business collaboration evaluation for sustainability?
3. How does evaluation of university-business collaboration projects contribute to their sustainability aims?

A title/abstract keyword search was completed highlighting three terms used to describe university-business partnerships: "co-creation", "co-production" and "third-mission". As university-business collaborative projects span a diverse range of topics, words stemming from "sustainab" (e.g., sustainability/sustainable/sustainably) were included to narrow the search to the most relevant projects. This resulted in the following keyword search:

TI/AB ("Co-Creation" or "Co-Production" or "Third-Mission" or "Third Mission" and "Sustainab")*

This search was deployed for articles in the English language within Web of Science, SCOPUS, and Academic Search Ultimate. Following deletion of duplicates, 324 papers remained. A screening process followed whereby abstracts were read and articles which were not relevant to the study were removed. This resulted in 101 papers which were fully read and analysed. Within the review, we also included articles recommended by peers alongside relevant citations within articles.

3. Results

3.1. Loss of Complexities of Place through Reductionism and Compartmentalisation

Compartmentalisation remains a dominant feature of sustainable UBC evaluation frameworks, with elements of a project commonly organised into discrete areas (e.g., "levels", "areas", "topics") typically in order to create an overall score or strategy incorporating various components of a project [12,13]. Compartmentalisation aims to deliver an all-encompassing metric for sustainability in order to provide easily comparable "benchmarks" for projects. Such proposed metrics include the Ecological Footprint, Urban Environmental Carrying Capacity and Index of Sustainable Economic Welfare (ISEW) [12,14].

Compartmentalist approaches can often be advantageous, allowing for delegation of key areas to their respective authorities and, in theory, ensuring that every area of the project is covered in a relatively equal depth [13]. Amidst academic institutions, with the creation of disciplinary boundaries, compartmentalisation can appear a logical option to break down complex social and technical structures into more digestible components [15].

Conversely, a reductionist approach whereby categorisation forms a major basis of a framework can result in little more than reorganisation of pre-known information, adding

little value to the thinking process. Reductionist frameworks have a tendency to result in problem-shifting and displacement which requires new modes of strategic thinking to overcome [16]. Reductionism can also lead to overly prescriptive frameworks limiting its potential to be used across sectors, particularly lending itself to application across technical fields where reductionist thinking is the most common [17,18]. A process which focuses thinking on individual components may confer a tendency to attempt to control for details in absence of greater perspective, risking that resultant decisions be made in absence of wider context [17]. Crucially, compartmentalisation unavoidably confers weighting to various elements of a project, lending itself to the (subconscious or otherwise) prioritisation of various elements of a project according to those responsible for managing the evaluative process.

3.2. Power and Place: Evaluation as a Neoliberal Tool

The subjective nature of relative "success" and "sustainability" has been discussed in detail [19]. Given their subjective nature, success and sustainability can be considered social constructs and are therefore entirely influenced by power relations within a social system [20]. Traditional frameworks of evaluation are generally mandated by those in positions of authority [21]. Consequently, evaluation is a means of assessing the degree to which the subject of said evaluation aligns with the ideals of those mandating the evaluation [22]. Through this means, metrics risk being (constantly re-) aligned with the priorities of those in positions of power with the terms "constraint", "control" and "compliance" frequently associated [23].

Alongside being a product of power relations, evaluation can also itself act as a means of perpetuating and/or reshaping power relations within UBCs [24]. The inert nature of metrics has also been questioned, with metrics themselves described as having their own agency through the influences they indirectly exert [21]. Another consequence of authoritative evaluation methods is a focus on short-term, measurable results. Neoliberal thinking relies on rational decision making whereby actors require impartial and comparable data, specifically for the purpose of constructing (quasi-)markets and spheres of competition as the supposedly "optimal" governance structures for the good or service in question [25]. Quantitative data has a tendency to be viewed as objective and relatively free from external influences. This, combined with the difficulty in accurately forecasting long-term sustainable effects of projects, makes them frequently preferred sources within modern evaluative frameworks [24,26]. Yet the very concentration on short-term metrics tends to entrench such short-term concerns as the primary drivers of decision-making.

3.3. Local vs. Global Context

Within UBC for sustainability, regional development is frequently a core parallel aim of a project [2]. Despite this, although the actions within a UBC programme are frequently reported with some degree of reference to local region, the impacts or outputs of these projects are usually reported on a universal level [27]. For example, Carragher et al. [28] report a study of an Irish community which participated in a co-creation activity incorporating place-focussed methods. Results were reported as reductions in ecological footprint, aligning with universal metrics, yet there is no measurement of local impact, despite anecdotal reports that a significant contributor to this reduction in ecological footprint was achieved on a local level through reductions in car usage and household waste. Given that the socio-economic effects of UBC are typically concentrated around their host localities, it can be expected that therefore at least some degree of environmental benefit would be expected to be felt locally [29,30].

This example is indicative of several studies, with the regional context being mentioned only in certain areas of the process (in a typically anecdotal manner) rather than followed through from start to finish [31]. Frequently, local environmental issues are seen as separate from global issues and consequently, local action (though recognised as important) is considered a separate battle from widespread issues such as climate change. In reality,

the two are not mutually exclusive but complementary, with local agendas acting as a necessary step to achieving global aims [31]. Crucially, this reporting method has a tendency to undervalue the effects of UBC by undermining the importance of local sustainability.

Evidently, sustainable UBC projects have a higher purpose on the unforeseen journey to sustainability as hubs of innovation, research application and local action, yet traditional sustainability metrics fail to capture the significance of this [32–34]. Equally, university-industry research output metrics have been found to have prominent inconsistencies that do not accurately depict their value within the institutional landscape [35,36]. Without urgent reconsideration of metrics and evaluation format, sustainable UBC projects risk being significantly undervalued and reported unfavourably within the policy landscape.

4. Discussion

One potential consideration for fulfilling some of the shortfalls discussed is an evaluative method more grounded in place. This approach has been proposed on a small number of occasions in various case studies (see Bentley and Pugalis [37] Hart et al. [38] Tan et al. [39]). Although the mechanisms vary, these place-grounded approaches commonly follow a way of thinking which gives greater priority to local and regional actions on different scales and considers this 'context' of place as an active and dynamic variable within a UBC project as opposed to a passive site of activity. Here, a place is not simply considered a geographical location but instead a space entrenched in meaning, encompassing social relations, power balances and the people themselves who interact with and within this space. This approach offers a different perspective in the context of UBC evaluation for sustainability alongside various considerations, which will be discussed in due course.

4.1. Reframing Problems and Solutions

The rationale for exploring a place-centred approach more seriously arises directly from the characteristic nature of most university-business collaboration projects. UBC projects frequently target regional development, focusing efforts within the locality of the partnership in question [2]. These projects are often relatively small-scale initiatives working in partnership with small-to-medium enterprises (SMEs) [2]. It is unreasonable to expect that these regional, small-scale projects have a tangible global impact. Evidently, the greater value of UBC for sustainability lies elsewhere on a regional or local level [27].

A consideration of place lends itself to allowing outputs and processes to be investigated from a regional perspective [40]. This takes steps to avoid some of the aforementioned fixation on universal sustainability metrics. In addition, it is equally mistaken to consider that UBC projects for sustainability are not influenced by the place in which they are situated. Instead of following traditional evaluative approaches, whereby 'context' is a variable to be controlled to maximise comparability, consideration of place within evaluation shifts this perspective.

By considering the dynamic nature of a project's local area, such as seasonal or economic fluctuations, the project can be better tailored for regional development, for example, rapid responses to the regionally-specific effects of the COVID-19 pandemic [41]. Boundary navigation, the interface whereby knowledge translates into action, must be considered a dynamic, continually changing process amidst the equally dynamic backdrop of place [42]. In addition, by avoiding the need for absolute comparability, which renders regional disparities a variable to be controlled, the regional elements of a project can be individually considered. Here, more realistic predictions can be made for transferring practices between regions, allowing for regional differences [43].

Taking this approach further, when considering the embeddedness of social relations within the place, it becomes impossible to think of a place without considering the power relations which shape it. Equally, the influence of place and the way in which its structures shape power relations become inescapable from consideration.

Although this is far from remedying the mechanisms by which evaluation is entrenched in power relations, an understanding of the power relations at play within a

project makes some steps towards addressing any underlying power tensions. To make further progress, assumptions regarding the agents responsible for evaluation need to be challenged, potentially through the consideration of participatory evaluation methods.

4.2. Participatory Evaluation

As UBC projects aim for partnership and more equitable power distribution, evaluation thereof should not escape such scrutiny. Beyond reinforcing existing tropes and power relations, such top-down methods of evaluation pose an ever-greater threat to sustainable development. Top-down evaluative methodologies limit the potential for wider and more equitable knowledge sharing. Reed and Abernethy [44] identified the benefits of lateral knowledge sharing (within similar initiatives) alongside vertical knowledge exchange and its value within co-production efforts such as UBC. The co-production of metrics can result in not only a more balanced representation of a project but the opportunity for stakeholder perspectives to shed light on previously unseen elements of a project which can yield valuable learning opportunities for future projects [23]. There are some concerns that top-down evaluation also results in under-reporting of project failings, limiting future learning opportunities [27].

However, the dangers of shallow democratisation must be recognised. Although a popular topic within evaluation studies, some argue that participatory evaluation as a concept is overly ambiguous and insufficiently theorised [45]. The language surrounding participation, democratisation and fairness can also be deployed as a superficial buffer to avoid scrutiny whilst keeping neoliberal, top-down approaches firmly in place. For example, Turreira-García, et al. [46] reviewed the so-called participatory evaluation of environmental projects found that the majority of projects only involved local communities in data collection whilst the creation and design of projects continued to take place in an authoritative manner; this is an effective compromise for authorities as it reduces the costs involved in data collection without sacrificing any material power within the project. Voorberg, et al. [47] demonstrate that participation of citizens in the co-creation processes is often viewed purely as an objective to be met with relatively little thought given to the beneficial contributions that citizens can add to the process itself. Co-creation alone is not sufficient and must be incorporated alongside co-governance to ensure a true democratisation [48]. Participatory evaluation measurements can prove to be useful in ensuring that democratisation goes beyond well-worded intentions [49], but even within these frameworks the danger of superficiality remains and can in practice act as little more than a tick-box exercise for institutions [50].

Greater consideration of the local lends itself to participatory evaluation through the greater weighting of the importance of local and lived knowledge [8]. Involvement of local communities allows greater tailoring of projects to the individual needs of a locality, increasing value gain both for regional economic and sustainable development [1,51,52]. In addition, local knowledge and stakeholder input can aid boundary navigation and greater diffusion of knowledge between universities and local businesses, acting as a valuable intermediary with shared perspectives [53]. Co-production of indicators and metrics incorporating local social and spatial contexts can also act as a valuable learning tool for developing shared understandings and building collaborative strategy [23,54].

More generalised sustainable development strategies have been found to be ineffective and impractical when faced with a particularity of individual places; local actors have been shown to possess the necessary skill set to map local decision processes and identify otherwise unforeseen regional characters [39]. Place-minded evaluation not only prioritises local knowledge and stakeholder perspectives but gives a greater voice to place itself through valuing local input.

4.3. Navigating Boundaries

Boundary navigation is frequently cited when discussing UBC, particularly regarding the translation of knowledge into a workable action [42,55,56]. In addition, sustainability is

noted as an interdisciplinary and indeed transdisciplinary issue [57–59]. The navigation of disciplinary and sectoral boundaries, alongside the facilitation of mutual knowledge and resource exchange between social worlds, is one of the cornerstone challenges we must confront to make significant strides towards a sustainable future.

Place offers a unique opportunity here to transcend disciplinary boundaries and the knowledge-action barriers. Hart et al. [38] found that working at a scale of a single region and local place provides more frequent learning opportunities; Chammas et al. [55] identified common interest between researchers and the community as a core value in successful co-creation, citing participatory mapping and place-based study as a key means to achieve this. Shrivastava and Kennelly [29] have emphasised the utility of regional approaches to evaluation in navigating boundaries, maintaining that place-based enterprises are more likely to engage in UBC to pursue environmental, social and economic outcomes when compared with conventional enterprises. Place-based opportunities have also been highlighted through the ability to combine researchers' explicit knowledge with the tacit knowledge of local stakeholders [39,51,60]. It has been reported that many key performance indicators are not relevant to all stakeholders within UBCs [33]. Local indicators for project success could provide an opportunity for a common goal which has higher relevance for all parties involved [61].

To break down the disciplinary and sectoral boundaries which have been constructed over decades (if not centuries), transdisciplinarity needs to be introduced within traditional education methods. At present, the relative isolation of disciplines can make it difficult for students to gain an interdisciplinary skillset [18] with sustainability students reporting feelings of disconnect from the climate story with a lack of ownership [62]. Place-based teaching and learnings foster unique opportunities to diversify learning experiences across a range of disciplines with the place and its social relations shown to have inherently pedagogical qualities [63,64]. By combining industry and academia in the crafting of curricula, both tacit and codified knowledge can be utilised to maximise learning potential [65,66]. Living labs, whereby students work directly across academia and industry to understand and tackle situational problems across campuses and local regions, have shown to be highly effective, particularly in the context of sustainability education [67,68]. Living labs have additionally been shown to be effective in the evaluative process, allowing the wider involvement of stakeholders in both the proactive and reflective stages of evaluation through clear relation to local and regional contexts [69].

5. Conclusions

From this study it can be concluded that, considering the significance of UBC for sustainability, significantly greater attention should be given to critically re-evaluating current evaluation methods. Without considerable effort, UBC projects for sustainability risk being undervalued (through lack of consideration of local and regional impact), exploited for individual gain (through the top-down, power-entrenched nature of evaluative mechanisms) and over-generalised (through the extensive use of reductionist approaches to evaluation). This study finds one potential ameliorator: greater consideration of local and regional contexts across all elements of UBC projects for sustainability through a place-centred approach.

This paper is by no means a guide for evaluating UBC sustainability projects, nor does it pretend to have all the answers for crafting a place-focussed evaluative framework. Rather, it merely aims to emphasise the importance of the evaluation of UBCs within the wider sustainability debate and identify potential areas for improvement. Although focussing on place fosters opportunities for improved evaluative practice, this perspective should certainly not be viewed as a silver bullet; indeed, embracing the complexities and individualities of place can illustrate the infeasibility of such silver bullet thinking. Practical considerations of scalability, comparability, longevity, and accessibility must be confronted with regional considerations likely used as a complementary element to a framework rather than an all-encompassing ethos.

There is clearly great scope for future research within this area. First, consideration of how regional and local focus could manifest in a practical evaluation methodology. Secondly, there is a demand for consideration of how to navigate the trade-off between specificity, scalability and comparability within the evaluation. Thirdly, mechanisms are required to ensure true participatory evaluation within UBCs and avoid superficial democratisation of evaluative methods. Other key areas include the use of evaluation as a neoliberal tool, the role of UBCs as boundary facilitators within the sustainability debate, potential remedies to the ambiguity of sustainability across disciplines and sectors and the greatest barriers to place-centred evaluative practices. Significant attention is required in this field to improve the potential for UBCs to deliver equitable and sustainable outcomes.

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Proceeding Paper

Our Experiments with MOOCs: A Study on Using Blended Learning Pedagogy in Faculty Development Programs at IIMBx; Pilot Project: Strategy and the Sustainable Enterprise for Teachers †

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Abstract: Mainstream sustainability education in India is at a nascent stage, with a small and gradually growing number of institutes offering it at a graduate level. There is a need for a community of educators skilled to teach sustainability and who have the ability to utilize technological capabilities for the same. In this paper, we explore the journey of our pilot project—Strategy and the Sustainable Enterprise for Teachers (SSET)—a blended learning program. We detail the steps that went into designing this program to create a national community of sustainability educators. This program makes a case for the potential of using blended learning as an effective method to create a community of practice beyond physical boundaries. Our study will focus on the role this program's design has in the current scenario, which calls for a keen focus on digital media.

Keywords: education for sustainable development; teacher education; community of practice; blended learning; sustainability for businesses; sustainable enterprises

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1. Introduction

Sustainability is one of the foremost challenges our world faces. By playing a central role in development, resource utilization, and job creation, businesses have the potential to channel growth in several Sustainable Development Goals' parameters. With extreme events increasing pressure on the ecosystem, there is a growing relevance of sustainability education in the Indian context. Strategy and the Sustainable Enterprise for Teachers (SSET) enables teachers from anywhere in the country to teach sustainability in their own classes with a focus on business, management, and entrepreneurship. SSET had 14 weeks of online engagement and concludes with a face-to-face workshop on campus. The course content has learning components such as videos, interviews, webinars, simulations, and a research project, with the objective to promote collaboration, peer-learning, reflection, creativity, and mentoring.

This paper describes the journey of the pilot project in IIMBx—the digital learning department at Indian Institute of Management Bangalore—a blended learning program for management and business educators. We report the steps that went into designing this program and use a case study method to detail the steps that went into creating an international community of practice of educators passionate about sustainability. Our key questions were: How does a created national community of practice for Education for Sustainable Development shape business education in the country? What are the implications of the new knowledge created in combining online and offline spaces of interaction for the course design?

For faculty to easily take this up alongside their normal academic duties, SSE for Teachers spanned 14 weeks of online engagement and concluded with a face-to-face workshop on the IIMB campus.

The Indian Institute of Management, Bangalore (IIMB) has been promoting education and research in management since its inception in 1972. To meet the need for professionals skilled in the principles of Sustainable Development, IIMB has designed a course titled Strategy and the Sustainable Enterprise, which has been taught in the classroom for the last 20 years and adapted as a MOOC in the previous 5 years. In 2019, SSET—a blended learning program was created to reach educators in business institutions all over the country to promote ESD and create a teachers' community and resources to reach students across India. The teachers' version of the course was adapted from the earlier runs of a similar course that was successfully run multiple times over edX.org and Swayam, the Government of India's learning portal; several thousand students have completed the same. While the course had learning components typical of MOOCs such as video lectures, case studies, interviews with industry leaders, and exercises, this was supplemented by weekly webinars, group simulations, and a collaborative research project.

2. Relevance of the Study

Given the critical nature of India's ecological challenges, it is imperative for institutions of higher education to infuse sustainability-related topics urgently and proactively into their curricula. While the number of business schools in India exceeds 4000, sustain ability education in India's B-schools has not been very effective due to the following reasons:

- Sustainability is still not seen as a mainstream functional area by B-schools. This has translated to the absence of a supportive infrastructure and incentive system and a reluctance to recruit specialized faculty at these institutions.
- Except in the case of a few specialized programs, sustainability courses are primarily driven by faculty interests. The effectiveness of these courses depends on continued faculty interest, something that is difficult to sustain given the wide variations in student interest and institutional support.
- Many schools suffer from a shortage of faculty, even in the traditional disciplines of management and business. Consequently, assigning/motivating faculty to teach courses such as environmental management has been doubly difficult.
- There is an absence of easily accessible and affordable teaching material, including cases, videos, articles, and books.
- General lack of industry support and recruiter interest translates to low levels of student interest in sustainability-related courses.

3. Review of Literature

Some of the earliest discussions on sustainable development originated from an economic perspective—whether the Earth's limited natural resources would be able to infinitely support the increasing human population. This was supported by Malthus and his theory of population growth in the early 1800s, as reported by Dixon and Fallon [1]. If measures were not taken to check the rapid population growth rate, these finite resources could become exhausted. In 1972, the Limits to Growth study outlined new connections between industrial production, pollution, and population growth and emphasized that exponential growth would eventually result in a saturation. This was observed by Basiago in 1999 [2]. It is documented that the concept of sustainable development gained importance and momentum at the first Earth Summit. There was a consensus among the international community, which agreed to manage development and the environment in a mutually beneficial way, as stated by Mensah and Casadevall [3]. Since then, conversations have become more nuanced to go beyond population growth and include resource utilization, wealth distribution, and political and social structures. The process of resource selection has an impact on a firm's competitive advantage and longevity. The advantage depends

on its ability to manage the institutional context of its resource decisions, as reported by Oliver [4].

Given the context of mainstreamed conversations on sustainable development at the level of the firm and its ecosystem, corporate sustainability initiatives have flourished, driven by a desire to minimize costs and risks, maximize opportunities, and enhance reputation. Van der Waal and Thijssens observe that at the heart of corporate involvement in sustainability lies a need for a shift in corporate culture [5]. By playing a central role in development, resource utilization, and job creation, Bebbington and Unerman state that businesses have the potential to channel growth in several Sustainable Development Goals' parameters [6]. In this context, business education needs to redefine how students engage with societal and personal development. To situate India in global discussions on sustainability education, in the country there is an increasing urgency to embrace alternate forms of development that reduce negative impacts of climate change on economic and social systems. This is discussed by Sathaye, Shukla and Ravindranathan in 2006 [7].

Studies have posited that to contribute meaningfully to sustainable development and create related work environments, it is important for students to be able to effectively engage with society and be change agents. To train faculty for this future of education, they should be able to deliver courses aligned with social objectives [8,9].

Studies suggest that learning for educators can be empowering and innovative in a community of practice [10–13]. Jho and Song compare the community of practice model in two selected schools in Korea. They observed it created an atmosphere of innovation and open mindedness, and a vast document of shared resources [10]. In Portugal, formal and informal communities of practice for educators have helped promote sustainable development by developing educational resources, sharing innovative practices, and collating perspectives from multidisciplinary learners [11]. Grand Rapids, the first Regional Centre for Excellence, was created as a concept for social learning to build sustainable communities via structured interactions between actors such as institutions, schools, civil society, and enterprises [12]. At the University of Tasmania, a multi-stakeholder community of practice was established to bring together staff and the wider community and influencers to discuss the student experience, community engagement, and institutional leadership [13].

While there is work around communities of practice in sustainability education in other geographical contexts, the Indian context, especially higher education, needs substantial contributions to research on the role of educator communities of practice to further sustainability education. The identified gap in the literature points to the need to investigate the role of communities of practice for ESD in business education in India, using both virtual and offline spaces. The problem statement is that sustainability education in the business education ecosystem in India is conducted in silos by individual faculty with inadequate knowledge-sharing.

We designed the blended learning program for educators in India to address two pressing challenges: Can an effective faculty development program be designed to have the scalability to reach an audience across the country? Can the program be made as affordable as possible and scaled up easily to serve the broader agenda of mainstreaming sustainability education in the business education space and create a community of meaningful exchange?

To mainstream sustainability education in the business sphere, the program operated with the following objectives: Creating a national community of teachers who are passionate about sustainability in business education and can contribute to teaching and research in the field, developing a vast repository of knowledge, resources, activities, and cases to be used to teach sustainability to students of business and entrepreneurship; and designing an environment in B-schools to foster project-based learning in areas concerning the Triple-Bottom-Line, namely Society, Environment, and the Economy.

4. Rationale and Research Objectives

Over the last decade, the introduction of new technological innovations addressed the setbacks of online learning with respect to face-to-face sessions. Guzer and Caner observe

that blended learning combines distributed learning environments [14]. This optimizes time, access, and reach and opens global channels of collaboration. Developments in technology encourage teacher educators to apply blended learning in their classrooms.

Projects need to be outcome-focused, and well-structured and planned by paying attention to important details. These details should offer a clear path between understanding the context and finally establishing learning systems. Designing a program that was the first of its kind in the IIMBx portfolio called for structured communication and engagement between subject matter experts from teacher education, higher education, instructional design, and sustainability.

SSET was built using the principles of blended learning to augment a course that had been taught in the classroom for the last 20 years and online for the previous five. The design of the program and determining the appropriate blend ratio depended on several factors. Blending is experienced personally and individually by students. Much of what is defined as blended learning is blended teaching that reflects pedagogical arrangements.

Several papers identify components of the blend such as assessments, online mentorship, e-mail, computer laboratories, and other means of internet access such as mobile computers and phones, mapping and scaffolding tools, interactive presentations, collaborative portfolios, learning management systems, and other virtual and offline infrastructure [15–18]. Every blended learning program cannot be considered equivalent. For SSET, the premise was an online program with a 1-day workshop. The design and evaluation of the program was in the context of conducting a pilot with the intention of scaling it across disciplines taught at IIMB. In a format that makes the education more experiential and research-oriented, the course targeted educators, customized with classroom resources, interviews, articles on sustainability, case studies, simulations, and a collaborative research component, amongst other tools.

We designed the blended learning program for educators in India to address two pressing challenges: Can an effective faculty development program be designed to have the scalability to reach an audience across the country? Can the program be made as affordable as possible and scaled up easily to serve the broader agenda of mainstreaming sustainability education in the business education space and create a community of meaningful exchange?

SSE for Teachers was designed with the following objectives in mind:

- To create a national community of teachers who are passionate about sustainability in business education and can contribute to teaching and research in the field.
- To develop a vast repository of knowledge, resources, activities, and cases to teach sustainability to students of business and entrepreneurship.
- To provide teachers with the resources to create courses in their institutes relating to sustainable development or embed this lens in their existing courses.
- To design an environment in business institutes to foster project-based learning and action in areas concerning sustainable development.

Other factors that determined the course design included the following:

Digital access: Research on digitalization and development in the Indian context points out that the socio-economic benefits of digital technology often depend on a set of economic, social, and institutional dimensions. In India, policymakers have used digital interventions to address economic growth and social inclusion challenges. Universal digital adoption in the country can enhance productivity, integrate geographies, improve participation, and provide suitable investments in developing the requisite infrastructure and skills. India has the lowest mobile data prices in the world. The course is made available through a website and a mobile application, and fortnightly webinars can be accessed through the internet as well. The course, over its 14 weeks online, through a Massive Open Online Course and webinars, explores the emerging relationships between sustainability issues and competitive advantage.

A community for collaboration: Building on the basic concepts of sustainability and strategic management, academics can design courses for future managers to effectively deal with the sustainability challenges they will encounter. Each week of the online

course has a section for educators to contribute their classroom ideas and local research, which is discussed on the forum with the facilitators and peers. Having an online course often implies a static, one-way conversation that could end up having a one-dimensional narrative of sustainable development. We wanted this course to have 'glocal' perspectives ('glocal' as used in a book published in 2017 on multicultural education) [19], where we can draw from insights across the world and the local contexts of our participants as well. Each week, we have modules that invite teachers to share their research and classroom activities with the rest of the participants and us to make learning more collaborative. For example, we use digital tools such as discussion forums, games, and participant-led thematic activity creation.

Scalability: The traditional Faculty Development Program model at IIMBx reached about 14,000 faculty over five years. By going digital, the course opens up to a pan-Indian audience by reducing the costs involved. Our pilot program started with the small number of 39. With the appropriate Information Communication Technology (ICT), the program can scale up to educators across India and potentially the world for programs across disciplines.

Pedagogy (design in Appendix A): To explore innovation in blended learning pedagogy, the program integrated business simulations designed for sustainability by MIT Sloan School, covering clean energy, the solar industry, and climate change agreements. Instructors guided 'learner' participation and gameplay. These simulations were made accessible to learners to engage within their own classrooms. To leverage the open-source tools in educational technology, apps like Padlet, Flourish, and others were used to develop and visualize data. To encourage education for sustainable development, Harvard Business School Publishing provided cases, articles, and other curated reading material for free to the participating cohort.

Research and mentorship: By designing a research project as part of the course, we created a network of researchers who otherwise would have never collaborated based on their subject areas. Learners had access to free material, classroom activities, and personalized mentorship. They presented papers, and some of these were published in reputed journals.

5. Analysis and Discussion

Addressing the challenges of infusing sustainability into traditional curriculum calls for a multi-pronged strategy, including enhancing institutional capacity. Efforts at building institutional capacity in terms of faculty skills, access to teaching resources, and creating a critical mass of interested faculty are urgently needed. This blended program attempted to overcome the barriers in two ways: one, by leveraging technology and external partnerships to provide inexpensive and accessible teaching material on sustainability in the business context; and two, by facilitating collaborative research on critical issues among participants from multiple institutions using a digital platform, allowing professional networks to develop and quickly transplant successful experiences between schools and help evolve collaborative curriculum development, case writing, and research efforts.

We faced challenges in achieving one of the objectives to co-create a repository of resources for educators. Every week, we had activities to encourage participants to create resources and share how they used them in class. Contributions to this section died out, and we have yet to investigate what to attribute this to, whether it is methods of engagement, time, learning nudges, or other reasons.

While the advantages of using MOOCs for student learning has been highlighted in the literature, the use of MOOCs for scaling up teacher training has not been explored adequately. This study highlights the potential for using MOOCs to fill the resource and capability gaps that continue to exist in several countries of the world.

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Appendix A. Strategy and the Sustainable Enterprise FDP: Blended Learning Map

The tables below contain all the elements of the overall course design mapped to the learning objectives and expected outcomes.

Table A1. Legend.

Week Title
Online MOOC Content
Additional Readings
Weekly Webinars + Simulations + Guest Talks
Classroom Aid
Research Paper/Case: Group Activity
Faculty Project: Individual Activity

Table A2. Blended Learning Map.

Strategy and the Sustainable Enterprise FDP: Blended Learning Map				
Week 1	Week 2	Week 3	Week 4	Week 5
What is Sustainability and Why Should Strategists Care?	Managing Stakeholders	Managing Sustainability Risks	Transforming into the Sustainable Enterprise	The Anarchist Corporation
Introduction to Sustainability	Introduction to Stakeholder Management	Introduction to Risk Management	Introduction to Corporate Sustainability	Introduction
The Changing Landscapes of Business	The Stakeholder Theory of the Firm	Assessing Sustainability Risks	Tools and Techniques	New Business Models for Sustainability
New Rules of Doing Business	Managing for Stakeholder Value	Managing Issues	Green Supply Chain Management	The Anarchist Corporation
Weekly Webinar: Introductions of participants And Introduction to course design—Professor Jose				
Additional Readings: • Systems Thinking: A Cautionary Tale • Planetary Boundaries • Limits to Growth • Our Common Future • The Skeptical Environmentalist • A Safe and Just Space for Humanity + Cases courtesy Harvard Business School Publishing + Research papers for reference	Stakeholders and Non-Market Strategies	Managing Risks in a Global Context	Company Case Studies	Corporate Stories
	Weekly Webinars: Webinar 1: Case for teaching sustainability—Professor Jose Webinar 2: Research propositions by participants	**Weekly Webinar:** Research Updates 2.0		

Table A2. *Cont.*

Strategy and the Sustainable Enterprise FDP: Blended Learning Map				
Activity 1: Classroom Aid: The 'Systems Thinking: A Cautionary Tale' video you watched illustrates the importance of systems thinking. It is a reminder that when we don't understand the inter-relatedness of things, solutions often cause more problems and simple questions often require complex and reflective thinking if good solutions are to be found. Faculty can ask their class to come up with an example of systems thinking. Students will need to present a sustainability challenge and then a solution for the same, using systems thinking.	**Additional Readings:** • 30 years after Union Carbide • Power/Interest stakeholder grid • HBO Chernobyl	**Additional Readings:** • Unilever: Internal Risks and Engagement • HUL: External Risks and Engagement • Corporate Political Responsibility • Tata Factory in Singur, Kolkata • Woke-Washing	Sustainability Reporting	Synthesis and Summation
Activity 1.1: Classroom Aid: *'What role do businesses play in influencing the planetary boundaries?'* **OR** *'The Skeptical Environmentalist was published in 1998, what would look different now?'* Class students could come up with past and future roles, and suggestions for their line of work.	**Activity 1:** Classroom Aid: Faculty can use the Bhopal case study in their classroom.	**Activity 3:** Classroom Aid: The material on HUL talks about risks in the company and various stakeholders affected by this. Risks cannot be viewed in isolation and not dealing with them can affect the company's reputation. Students could design one stakeholder engagement activity for a 'risky' stakeholder. For example, a focus group discussion, a round table, etc.	**Weekly Webinar Series:** Simulations: 5 days, 8 faculty per day, 3 simulations from MIT. 1. CleanStart 2. Solar PV Industry 3. WorldClimate **Additional Readings:** • Kalundborg Corp • Costs and Benefits of Sustainability Certifications • Tool: True Value • Integrated Reporting • Mindtree's Integrated Report	**Weekly Webinar:** Talk by John Ehrenfeld on flourishing vs. sustainability **Additional Readings:** • Alibaba and Sustainability in E-commerce • Patagonia and clothing design • Uber and the ethics of a sharing economy • Transport in Denmark

Table A2. *Cont.*

Strategy and the Sustainable Enterprise FDP: Blended Learning Map				
Group Activity 1.2: Research Interest: Faculty collaborate according to their research interest and begin to work on a paper during our engagement.	**Activity 2.1:** Classroom Aid: Students in teams could come up with a Stakeholder Engagement Grid for various organizations like a local municipality, FMCG business, an eco-tourism cooperative, etc.	**Activity 3.1:** Classroom Aid: Students can design a video advertisement for a company that implements sustainable practices and present it in class.	**Activity 4.1:** Classroom Aid: Students could create a video of a self-designed closed loop system like the industrial symbiosis explained in the video.	**Activity 5:** Classroom Aid: Students could design one aspect of what they imagine to be a smart city: transport, waste management, ecosystem conservation etc. Example: Reference Video This video explains how bus ridership jumped by more than 70% between 2012 and 2017 in Kingston, ON. Dan Hendry discusses all about how they achieved that. He was part of this success story.
Activity 1.3 Design your Activity: Faculty can come up with their own activity to illustrate any of the learnings from Week 1 and share it with us to be made part of a repository of classroom activities. Note: Encourage faculty to explore activities in their classroom and share videos with us.	**Activity 2.2:** Faculty Project: Faculty are encouraged to could come up with a Stakeholder Engagement Grid for various organizations like a local municipality, FMCG business, an eco-tourism cooperative, etc. They can present this grid in the following weekly webinar.		**Activity 4.2:** Classroom Aid: Students could come up with parameters to design their own tool to evaluate sustainability in a system.	

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Proceeding Paper

The Missionary Approach to Development: Ensuring Inclusive and Equitable Quality Education for the Most Marginalized †

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Abstract: Missionary development organizations across all denominations are vital to providing quality inclusive education in developing countries, often being the only providers of quality education for marginalized people. Research conducted by Misean Cara shows how the Missionary Approach to Development Interventions (MADI) enables missionaries committed to social justice and the realization of rights to contribute to equitable quality education, especially reaching those at risk of being left behind. In their unique approach, missionaries address the immediate needs of learners worldwide by providing inclusive and equitable access to safe and quality education, while also supporting local authorities in the strengthening of their education systems, ultimately enabling them to fulfil their role as the primary provider of education.

Keywords: missionary approach; faith-based; development work; quality education; furthest behind; SDG 4

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1. Introduction

Historically, and to some extent up to today, secular development practitioners have been hesitant to engage with religious and faith-based or missionary organizations [1]. Yet, faith-based organizations and individuals play a crucial role in the provision of basic services in many places [2], and make valuable contributions to policy making, system strengthening and long-term impact. Today's development work by Irish missionaries is based on the principles of social justice and focused on rights, and missionaries are at the forefront in delivering quality services, especially in education and health.

Against this background, recent decades have seen a 'turn to religion' [3] and an increased international appreciation of the value of faith-based approaches to development and humanitarian work. This is seen in the numerous faith-based and missionary organizations with consultative status to the United Nations Economic and Social Council (ECOSOC), the high profile of faith-based organizations (FBOs) at the UN High Level Political Forum on Sustainable Development, the Faith Initiative started by the World Bank in 2014, and the establishment of the multi-donor International Partnership on Religion and Sustainable Development in February 2016.

For decades, Irish missionaries have played a significant role in advocating for human rights and social justice; they were pioneers in the evolution of Ireland's overseas development cooperation. Since the early 1970s, missionary development work has availed of funding through Ireland's international development program [4]. Today, Irish development funding for missionary development projects is distributed through the organization Misean Cara.

Although the role of some types of FBOs is contested in certain aspects and contexts, given the centrality of public service education, organizations such as those discussed in

this paper play a crucial role in advancing Sustainable Development Goal (SDG) 4 across the world. While the 2021–22 Global Education Monitoring (GEM) report warned that "without adequate regulations on private education or the capacity to enforce them, equity, inclusion and quality, the core principles on which SDG 4 is based, are at risk" [5], all projects supported by Misean Cara operate within government regulatory environments, with the vast majority being subject to national education authorities' reporting and inspection frameworks.

The 2021–22 GEM Report shows that there is often no crystal-clear distinction between public and private education—and governments support faith-based schools in 120 countries. Yet, it is crucial that state and non-state actors are working—separately and collaboratively—in the same direction, based on a recognition of state parties' primary obligations to ensure access, quality and systems that deliver the right to education. In addition to capturing concerns about some faith actors' practices, in some aspects and contexts, the Report notes an appreciation that faith-based and religious organizations "are often doing the essential work on the frontlines of combating extreme poverty, protecting the vulnerable, delivering essential services and alleviating suffering" [6].

Continuing Irish missionaries' global contribution to the UN principle of Leaving No One Behind—or, in their own words, to *reaching the last, the least and the lost* ("The last, the least and the lost" is a phrase that has been used by missionaries to describe the communities with whom they choose to work; it comes from three verses in the Gospel of St. Matthew (20:16, 25:40, 18:11))—Misean Cara supports a total of 88 missionary organizations in their development and, occasionally, emergency work. Project funding is exclusively provided for the development and humanitarian work of members; pastoral initiatives are not supported. Misean Cara members working in education, health, livelihoods, and sustainable development do not discriminate based on religion, just as they do not discriminate based on ethnicity, language, gender or politics: all support provided is equally available to people of all faiths or none. Misean Cara's members support some of the most marginalized and vulnerable communities worldwide to realize their human rights, as well as working for systemic change through advocacy, networking and community mobilization.

Over centuries, missionaries have been providing quality education to the communities they serve. Still today, faith-based organizations across all denominations are vital to providing quality inclusive education, often being the only providers of quality education for marginalized people. According to the Global Catholic Education Report 2021, 62 million children are enrolled in Catholic pre-primary, primary, and secondary schools globally (note that equivalent data from other faiths is limited), with numbers growing particularly strongly in sub-Saharan Africa [7].

2. The Missionary Approach to Development Interventions (MADI)

Research conducted by Misean Cara in 2017 provides a deeper understanding of the unique and successful approach missionaries take to humanitarian and development projects. All its member missionary organizations take their inspiration from Christian values and are guided by the same core principles of human dignity, social justice, the preferential option for the poor, solidarity, subsidiarity and care for creation. Projects are also influenced by their organization's particular commitment or charism. Furthermore, it was found that all Misean Cara member organizations are strongly committed to the core values of respect, justice, commitment, compassion and integrity.

Based on the findings of this research, a theoretical framework emerged (see Figure 1), describing the unique way of missionaries working to enrich and transform the lives of poor, vulnerable and marginalized people worldwide. This Missionary Approach to Development Interventions (MADI) [8] is defined by the following five distinctive features:

1. Crossing boundaries: Missionaries regularly cross boundaries, including those of nationality, identity, marginalization, and the accepted status quo. Missionary organi-

zations are international, and missionaries can draw on the technical resources and personnel of their global network.

2. Long-term commitment: Supporting communities for decades rather than for short project cycles allows missionaries to become deeply embedded in the communities they serve. Their strong local presence provides them with insights into the local context and social norms, and affords them a high degree of credibility, trust and influence within these communities.
3. Personal witness: A high level of dedication to their work, a simple lifestyle and solidarity with the poor allow missionaries to build trust and respect in the communities they live in and serve.
4. Prophetic vision: Striving for a better life for all, missionaries are unafraid of taking risks and forging new pathways, building on the inherent knowledge, strengths and capacities of communities to identify and address needs.
5. Holistic approach: Missionaries see and treat individuals and communities not just as project beneficiaries, but as dignified human beings with a wide range of capacities, needs and rights. This often manifests itself in projects that grow in size and scope over time (e.g., starting as an education project that soon also incorporates elements of psychological support, income-generating activities for parents and nutrition and health interventions).

While other development stakeholders may incorporate some of these features in their work, it is the combination of all five that makes the work of missionaries working for social justice—committed to human rights and aligning closely with the Sustainable Development Goals—unique within the international development sector. See Box 1.

Box 1. Example of the Missionary Approach to Development in South Sudan.

The Institute of the Blessed Virgin Mary (Loreto Sisters) in South Sudan established the first Girls' Secondary Boarding School in Western Lakes State in 2008. With this project, they cross many boundaries, being an international mission of Sisters and educating girls from different ethnic backgrounds to live and study peacefully together, despite the conflict that surrounds them. Girls are empowered to become confident and knowledgeable leaders, crossing cultural boundaries by enabling them to become doctors, lawyers, businesswomen or community leaders. The Sisters show long-term commitment to the school and wider community, keeping the school open throughout times of conflict and hunger. (Only COVID-19 restrictions forced them to close the school temporarily, while providing remote support to students.) The Sisters' personal witness is demonstrated by their dedication to living simply with the community and not fleeing at times of war and uncertainty. The Institute of the Blessed Virgin Mary was founded in 1609 by Mary Ward who had a vision at that time that 'women, in time to come, will do much'. This vision encourages the Sisters to take risks such as opening a school in a war-torn country without having all the necessary funding secured. They have been proven right, with their first students now having graduated from university. Thanks to the holistic approach taken, the Sisters address a range of social and cultural barriers to girls' education through innovative approaches such as family contracts of commitment to permitting their daughters complete their education. To reach their full academic potential, students and their families are provided with medical, nutritional, personal, and social support. More recently, the Sisters established a primary school and opened a health clinic, while also supporting the opening of a secondary school for boys in the area.

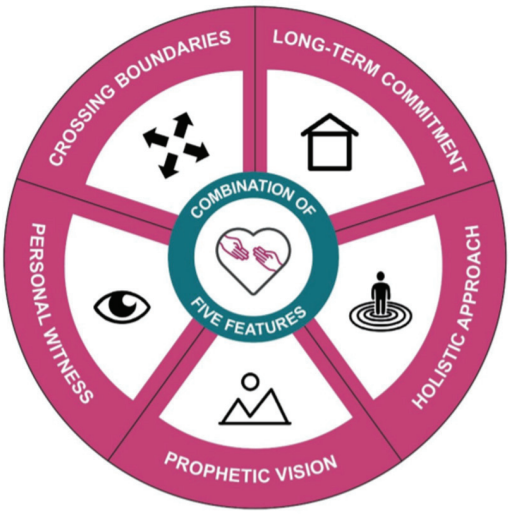

Figure 1. Five core elements of the Missionary Approach to Development.

3. Reaching the Last, the Least and the Lost

Misean Cara's 2020 follow-up research [9] further examines the degree to which the work of missionaries aligns with the global community's commitment, through the Sustainable Development Goals, to leave no-one behind while reaching those furthest behind first. The research found that the work of missionaries is closely aligned with Agenda 2030 for the SDGs.

Missionaries have a rich and distinctive vocabulary when referring to the people they serve. In the Gospels, there is not only recognition of the last, the least and the lost, but also frequent reference to the oppressed and the voiceless. A further reflection of this is the preferential option for the poor, used by Catholic theologians in Latin America in the 1960s, who "placed themselves firmly on the side of the poor, according to the Gospel's imperative to bring good news to the poor, proclaim liberty to the captives, and to set free the downtrodden" [10]. Here, "the poor" is understood in its broadest sense, including all those who are marginalized and vulnerable. This is closely aligned with today's understanding of "the furthest behind". While the language used by missionaries may differ from the terms common in the wider development community, missionaries have been working for centuries towards outcomes that align well with today's SDGs.

Misean Cara's missionary members particularly support those furthest behind by following a cyclical approach, which can be summarized as "Six 'A's". Figure 2 below shows how missionaries identify and target those furthest behind and continuously check to leave no one behind. See also Box 2.

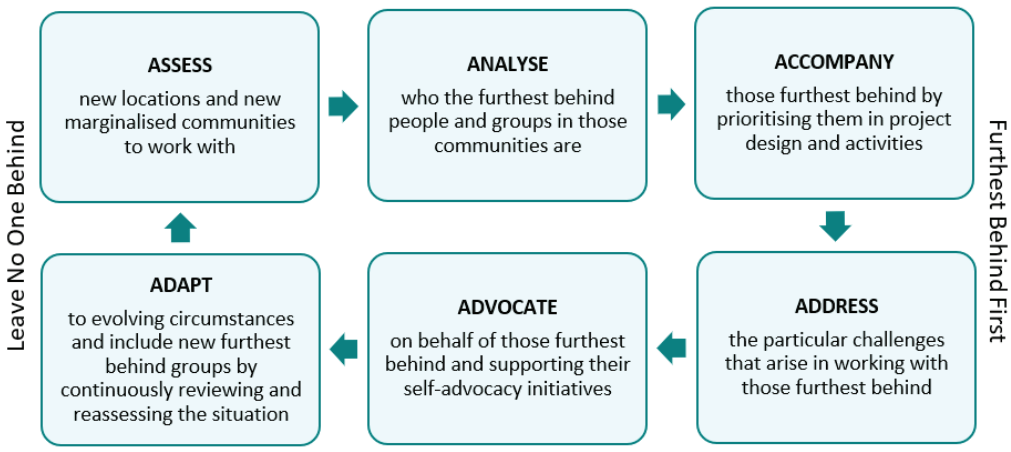

Figure 2. The Six 'A's approach.

Box 2. Example of the Six 'A's approach in Peru.

The Columban Fathers in Peru have close contact with marginalized communities through their daily parish work. Identifying children in disadvantaged areas as those furthest behind, they set up a project in one of the poorest neighborhoods of Lima to realize marginalized children's rights to justice, education, rehabilitation and a life free from abuse. Starting with a day center to provide a safe space for children while their parents were at work, the project soon expanded to include speech therapy, a Child Defense Desk, a home for children escaping domestic violence and a remedial school to help students who had dropped out of formal school. The project works closely with parents and teachers to reintegrate children into healthy family structures and mainstream schools, and advocates on behalf of children within the local community and public sector. The Columban Fathers and their lay project teams are recognized as leading experts on child protection in Peru and support other NGOs, schools and authorities in the review and strengthening of their own safeguarding approaches. They adapt quickly to changing circumstances, such as the recent influx of Venezuelan refugees and the COVID-19 pandemic. While the projects are established as independent NGOs to work in the long term, the Columban Fathers are known to 'leave when tarmac arrives' [11], i.e., when some degree of improvement comes to an area, which underlines their commitment to continuously search for and support those in greatest need.

4. Inclusive and Equitable Quality Education for the Most Marginalized

Misean Cara and its members recognize governments' vital roles and human rights obligations as core providers of quality education for all. Yet, in fragile contexts in particular, states are often unable to account fully for the educational needs of their populations. Even in non-fragile contexts, those furthest behind are particularly at risk of not reaching their potential through education. While access and inclusion are often mentioned in official policy documents in the countries where members work, the principles are frequently neglected (or inadequately addressed or resourced) in practice. Equity and quality considerations tend to be imperfect at best for disadvantaged groups in society, not to mention groups more systemically marginalized or excluded in certain states (e.g., for reasons of origin, ethnicity, caste, language, gender, religion, status or location) [12].

The Missionary Approach to Development Interventions, in combination with the aspiration to reach those furthest behind, inspires missionaries to contribute to equitable quality education, especially reaching marginalized people and groups. Living long term within the communities they serve, while maintaining strong national and international networks, missionaries find themselves in a unique position to address the immediate educational needs of those at risk of being left behind and also to support governments in strengthening their own approaches as education providers.

4.1. Leaving No One Behind

As part of the preferential option for the poor, Misean Cara members tend to work with communities that are neglected or disadvantaged in terms of education and, often, other basic dimensions of human development. Within marginalized communities, and migrant communities in particular (fueled by a fear of deportation), there is often a distrust of the state which can inhibit access to basic services. Missionary development projects can fit comfortably into the space between the marginalized community and the state, providing services and acting as intermediary, building trust and understanding, and encouraging integration.

For its Strategy 2017–2021, Misean Cara's missionary member organizations decided to make reaching people furthest behind, or at risk of being left behind, a shared objective, in line with their commitment to the Sustainable Development Goals and the SDGs' principle of Leaving No One Behind. As such, decision making on funding (particularly for larger amounts and multi-annual commitments) actively favors initiatives that are in remote or isolated areas, informal urban settlements, and conflict-affected or post-conflict areas. It also favors initiatives that target specific groups known to be at risk of being left behind, as the following project examples demonstrate:

- Girls—In South Sudan, girls are more likely to die giving birth than to complete high school [13]. In 2017, the country was ranked the world's most difficult nation for girls to access education [14]. In this environment, where only 2% of girls enroll in secondary school, a Loreto girls' secondary school enables 98% of its students to complete their secondary education through its holistic approach, incorporating community outreach to tackle practices such as GBV and early marriage, and supporting girls in their personal development.
- Children with disabilities—In Zambia, access to education remains a challenge, especially for children with disabilities, orphans and other vulnerable children. To address this situation, the Sisters of Sacred Hearts of Jesus and Mary opened an all-inclusive primary and secondary school to provide quality holistic and inclusive education to deaf blind children, offering technical vocational training, occupational therapy, and speech and language therapy. Opened in 1998, the school has become a center of excellence and is used as a national resource for pre-service teacher training in special needs education.
- Forcibly displaced people—In Lebanon, many Iraqi and Syrian refugee children remain culturally and linguistically isolated, and educationally disadvantaged. Most children do not attend school and fail to complete even one year of education. Against this context, a joint initiative by the De La Salle Brothers and the Marist Brothers offers a holistic education approach to grow stable diverse communities by intentionally mixing Christians and Muslims (Shia and Sunni), girls and boys, Syrians, Iraqis, and Lebanese. Special activities include language and basic ICT training to improve academic performance, pre-school courses to qualify refugee children for Lebanese schools, counselling and trauma healing, nutrition, socialization programs, gender-specific health classes, and livelihoods opportunities.
- Migrant communities—In India, entire families migrate seasonally to the brickfields of West Bengal. They generally do not speak the local language, leaving their children without access to education for a large part of the year. The Loreto Sisters' Brickfield Schools Project provides quality education in their own language to over 2500 children who travel to the brickfields with their families. The Sisters have designed several teaching resources including a "school in a trunk", which contains all the essential educational resources needed to deliver a class. The Sisters also work in the home areas of the migrant families, encouraging children to stay at home and not interrupt their schooling.
- Ethnic minorities—In Paraguay, the indigenous Ava Guaraní are often denied access to basic rights. After many years of lobbying by missionaries and a strong wider network, the Paraguayan Ministry of Education opened an office exclusively devoted to bilingual-intercultural education, and a Law on Differentiated Indigenous Education was passed. The Servants of the Holy Spirit support Ava Guaraní communities to prepare their own curriculum and textbooks in their language and relevant to their ancestral culture.

4.2. Contributing to Education System Strengthening

Misean Cara members promote a wide range of initiatives aimed at strengthening government policies and structures, practices and accountability. They also promote the right to education by supporting participation, non-discrimination and empowerment within the context of state laws, educational frameworks and regulation. Through increasing access and equity, testing and modelling good practice, awareness-raising, community mobilization, influencing stakeholders and sometimes more formal advocacy (as the context requires), missionaries engage duty bearers as to their responsibilities, and often help them build their capacities to fulfil their obligations [12].

Members operate within strong national and global networks of state and non-state actors, which allows them to support education system strengthening at both national and international levels, as the following examples illustrate.

The Redemptorist Fathers in Zimbabwe run an Accelerated Numeracy and Literacy project targeting out-of-school children with the aim of reintegrating them into formal education. The success of the project is such that most children enter a formal school within one year, where they receive the continuing support of the project to retain them in education. The project's methodology directly influenced a UNICEF program which was implemented nationally. The expertise developed on Accelerated Literacy & Numeracy Education has been shared with other organizations in Mozambique, Namibia, Zambia and Kenya.

In South Africa, Misean Cara has supported the Catholic Institute of Education (CIE), working through multiple congregations (Sisters of the Holy Cross, Salesians of Don Bosco, and Holy Family Sisters of Bordeaux) to contribute to building peaceful Catholic schools. CIE's interventions tackle violence, xenophobia and racism through whole-school restorative justice, peace-building and safeguarding approaches, in ways that are modelling change for the nation's entire school system. The initiative has recorded changes in school management practices for a peaceful psycho-social and physical environment; in the behavior of school leaders and teachers; in awareness and behaviors on child safeguarding; and in more harmonious staff and student relationships. A 2019 external evaluation noted that the initiative—implemented in 61 schools across 6 regions—is contributing to safer, fairer schools. For students, peer mediation training is also creating a means to participate in restorative approaches. CIE engages with statutory education agencies and makes inputs to the Department of Basic Education on draft policies and issues of safety and children's well-being [12].

Edmund Rice International, the joint advocacy body of the Christian Brothers and the Presentation Brothers, made a submission to the UN General Assembly on the Right to Education (2015), and joined the UN Special Rapporteur on the Right to Education at the 44th Session of the Human Rights Council (2020). To drive fundamental change, they have made 44 Universal Periodic Review submissions since 2012, including for all 24 developing countries where they have a missionary presence, and delivered 48 Oral Statements at UN Human Rights Council sessions.

Misean Cara members are active in the Justice Coalition of Religious at the UN (JCOR), as well as the NGO Major Group, the Women's Major Group, and the Major Group for Children and Youth. They are active year-round on the broad UN program of business on sustainable human development and engage strongly on the SDGs' principle to Leave No One Behind and the imperative to reach the Furthest Behind (often with a strong education focus), particularly while participating in the annual High-Level Political Forum process to review SDG progress.

4.3. Responding in Times of Crises

Reflecting their trusted relationships at the community level and experience working with particularly vulnerable or excluded groups, even when regional or national contexts are challenging, Misean Cara members have been quick in responding to changing circumstances such as localized outbreaks of violent conflict, severe climatic events or health emergencies—including the West Africa Ebola outbreak in 2017 and the ongoing COVID-19 pandemic.

In the latter case, thanks to their holistic approach, missionaries have been able to offer integrated approaches: not only responding to the educational needs of students but also addressing secondary effects of the pandemic, such as the resurgence of child labor and discrimination against girls, and a deterioration in children's health, well-being and physical safety. They have done so by incorporating well-being and life skills, family livelihood and food interventions, and community-based supports, as well as advocating for especially vulnerable cohorts. In addition, missionary-run schools have often been able to provide creative new forms of remote education when schools were forced to close.

5. Accountability

The 2017 Global Education Monitoring Report [15] focused on accountability for delivering SDG 4 targets and the mechanisms that can be used to hold all stakeholders to account for inclusive, equitable and quality education.

From local to global levels, Misean Cara's missionary member organizations are engaged with these mechanisms: monitoring teaching and learning, school leadership and community responsiveness; engaging parents, students, and community leaders; promoting teaching, school, and system standards; testing access and equity in using digital technologies; and advancing monitoring, evaluation and research.

At a macro level, they interact with state and international processes, exploring education policy and practice; promote ODA commitments, including a focus on poor and marginalized communities; and engage with the right to education through sectoral processes and human rights mechanisms—often bringing to the table the rights, and voices, of marginalized people and groups.

As private, not-for-profit education providers, Misean Cara missionary organizations are accountable at three levels:

- To the communities they live and work in, through structured school/project governance and accountability mechanisms;
- To national and district education authorities, since they act within national regulatory, educational and inspection frameworks, and collaborate to support state priorities and capacities;
- To peers in development and national/international donors, including through public transparency, audit and accountability mechanisms.

Additionally, Misean Cara members report annually on income, expenditure and results, but also on stakeholder engagement and alignment with government policies; on accessibility and inclusion; on their focus on marginalized people and groups; and on their contribution to education system strengthening. The data show that in 2019, members contributed in at least 17 countries to the preparation of national education policies or Ministry of Education annual work plans and led over 200 advocacy initiatives on inclusive education in 37 countries.

6. Conclusions

Missionary organizations have a long tradition of transforming lives by providing inclusive quality education around the world. In addition to delivering broader access to inclusive and high-quality educational services, Misean Cara member missionary organizations working for social justice—supporting human rights and aligning with the SDGs—use their knowledge, long-term commitment, expertise and experience to strengthen education systems. They influence teaching, learning, community engagement, school leadership and the enabling environment through modelling good practice; actively engaging in policy, processes, and methods; and through advocacy and campaigning. They work within the framework of government structures and policy, standard setting and regulation to advance inclusive and equitable quality education for all.

Evidence-based research commissioned by Misean Cara shows that the Missionary Approach to Development Interventions offers an effective way of reaching those furthest behind, in keeping with the imperative of the Sustainable Development Goals. Staying long term in some of the hardest to reach areas (often despite wars, natural disasters or health emergencies) allows missionaries to gain deep trust and respect within the communities they serve. This enables them to overcome cultural and social barriers, and turn their educational interventions into transformative experiences, especially for marginalized and isolated groups. In many instances, in the absence of government capacity, missionaries have been the only source of education for communities.

Misean Cara's missionary development projects are integrated into both local communities and local and national education structures, developing capacities and providing examples of innovation and best practice. Their focus on the dignity of each individual,

inherent in the Missionary Approach to Development Interventions, means that education can be a truly transformative experience for those who are furthest behind.

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Inclusion, Organizational Resilience, and Sustainable Development in Nigeria: The Role of Digital Innovations †

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Abstract: This study investigates the roles of digital technologies in promoting inclusion, resilience, and sustainable development in Nigeria. The study surveys relevant literature and concludes that the agricultural, e-commerce, financial, and transportation sectors majorly use digital technologies to promote inclusion, resilience, and sustainable development in Nigeria. Therefore, the study recommends that the Nigerian government and leaders of industries should work together and address the factors hindering the adoption of industry 4.0 technologies in Nigeria to minimize the possible effects of future internal and external shocks on the Nigerian economy. In addition, it is imperative that an incentive system that promotes digital innovations is developed to keep the country on the path of growth and sustainable development.

Keywords: digital innovations; inclusion; industry 4.0 technologies; organizational resilience; sustainable development

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1. Introduction

The digital revolution has contributed tremendously towards accelerating the pace of economic and social advancement across the world. It has impacted virtually all sectors of many economies and enabled the critical sectors to respond promptly to global disasters, especially pandemics. Digital technologies have provided a formidable platform that helps industries, most notably manufacturing, finance, education, medical, and communication sectors, mitigate disruptions that are associated with global crises, such as the COVID-19 pandemic, and drive inclusive economic growth, and sustainable development. Moreover, it has redefined government operations, customers' expectations, and business models. It has also impacted all aspects of life and livelihood, including communication, business, work, religious activities, leisure, etc. In addition, it has created an enabling environment for the actors in different walks of life to develop strategies and resilient approaches to achieve inclusive growth. Therefore, countries worldwide have leveraged digital and industry 4.0 technologies to address poverty and inequality, promote food security, boost productivity and provide an eco-friendly environment that is greener and decarbonized [1]. Technologies have also been used to stabilize the trading system, eliminate trade restrictions and curb the transmission of the COVID-19 virus in different parts of the world. China and India are among the countries that have recorded massive technology-driven economic transformation recently, and they are largely recognized as emerging advanced technology super-states across the world [2,3]. The transformative and sustainable development impacts of digital and industry 4.0 technologies have gradually been recognized in Africa. Over the last decade, digital technologies have contributed to skills and capacity development in Africa. In addition, it has provided the necessary tools to leapfrog the continent's traditional development trajectory [4].

Recently, African leaders developed Agenda 2063 to spruce up the standard of living, health quality, and wellbeing of the African citizens through education and skills acquisition, underpinned by science and digital technologies [5]. These efforts have yielded results, as many African countries have taken advantage of digital technologies to extend critical services to the underserved communities; digitalize their economic sectors; and improve financial inclusion, access to trade, and public services, thereby accelerating sustainable development. For instance, M-Pesa and Flutterwave, among others, have transformed the financial or banking industry in Africa. The flawless transaction services rendered by these companies enhance financial inclusiveness, uplift business activities, promote sustainable development, and help businesses circumvent the negative impacts of the COVID-19 pandemic. Similarly, mPedigree has helped bridge the gap between the rich and the poor by providing healthcare services both in urban and remote areas [4]. In addition, the use of industry 4.0 technologies has also helped to boost the continent's productivity and put Africa on the path of achieving inclusive growth and sustainable development.

In Nigeria, digital technologies have been used by governments, firms, religious organizations, agencies, and businesses to reach the forgotten communities, strengthen economic resilience and achieve the common goal of inclusive growth and sustainable development. Industry 4.0 technologies, including disruptive technologies, big data analytics, cloud computing, cyber-physical systems, internet of things (IoT), blockchain, artificial intelligence (AI), drone technology, autonomous machines, and simulation, have been employed in different sectors of the economy, most notably e-commerce, educational, financial, and transportation sectors to respond and adapt to incremental changes and sudden disruption. For example, while Jumia and Konga have digitalized the trading system in Nigeria, Uber, OPay, and Lara Transport leveraged digital technologies to transform the transportation sector [6]. Furthermore, Piggyvest, a digital financial platform is focused on making saving inclusive and has helped increase people's access to financial or banking services in Nigeria. Similarly, Zoom and Ulesson have enhanced the education sector, while different agrotech companies have leveraged cloud data solutions to advance the agricultural industry. On the other hand, industry 4.0 technologies, such as prefabrication and building information modeling (BIM), have been used to advance the construction sector's development in Nigeria [7]. Evidently, the COVID-19 pandemic has brought the need to intensify efforts in developing and adopting digital technologies in Nigeria, especially in the manufacturing sector. This is with the view to boosting the country's capacity and promoting growth.

This study, therefore, investigates the roles of digital technologies in advancing inclusion, building resilience, and supporting sustainable development in Nigeria. Specifically, the study identifies industry 4.0 technologies adopted in different sectors in Nigeria and explains how they are used to develop resilient approaches to sustainable development, inequality, and economic backwardness. Moreover, the study establishes how digital technologies could be used to minimize the effects of future global disasters in Nigeria.

Besides this introduction, the next section presents the conceptual clarification. Section 3 identifies and presents digital technologies adopted in Nigeria, as well as their impacts on inclusion, resilience, and sustainable development. In Section 4, the study discusses Nigerian digital economy policy and strategy, as well as the factors hindering the adoption of industry 4.0 technologies in Nigeria. Finally, Section 5 concludes the study, highlighting how technologies can be applied to future global problems in Nigeria.

2. Concepts of Digital and Industry 4.0, Digital Inclusion, Organizational Resilience, and Sustainable Development

Digital technologies or industry 4.0 technologies are the ingredients of wealth creation because they add value to goods and services in any society and ensure a good living standard for all [8]. Digital innovations refer to the application of new or digital technologies to existing processes to enhance the outcome of the procedures. The fourth industrial revolution is commonly denoted by industry 4.0, and it encompasses end-to-end digitization and

integration of all physical, digital, and biological assets into digital ecosystems. Industry 4.0 challenges the status quo and marks the beginning of new technologies, including mobile supercomputing, intelligent robots, self-driven and electric cars and neurotechnological brain enhancements [6]. It also enables a seamless generation, analysis, and communication of data through a wide range of new technologies [9]. Disruptive technologies, big data analytics, cloud computing, cyber-physical systems, the internet of things, artificial intelligence, drones, autonomous machines, and simulation are the driving forces of industry 4.0 that improve productivity and change the way people work and live [10].

The digital divide is peculiar to a developing or backward economy, an economy characterized by inequality. Digital divide is a situation where there is a wide gap among the people, groups, and communities in terms of access, distribution, and use of information, communication, and technologies. On the other hand, digital inclusion is attributed to a digital economy whereby all entities, including governments, firms, religious organizations, agencies, and communities, have the opportunity to contribute to and benefit from the digital world. Technical and operational capacities are prerequisites to navigating the ICT world [11] and governments, firms, religious organizations, agencies, and communities are expected to effectively access and utilize information and communications technologies in a digital economy. There are four types of resources around which digital inclusion revolves, and these are physical resources, including computers and network connections; digital resources, such as digital materials available online; human and human attributes, including literacy and education and finally, social institutions, such as communication institutions and social structures [12].

Resilience refers to the ability of a group, organization, community, or nation to resist shocks, respond and adapt to incremental changes and sudden disruptions or recover rapidly from shocks. It can also be defined as an economy's or a society's ability to minimize the adverse effects of a given magnitude of disaster on welfare. There are two components of resilience, and these are instantaneous resilience and dynamic resilience. While instantaneous resilience refers to the ability of an economy or organization to minimize the immediate loss of a disaster or shock, dynamic resilience denotes an economy or organization's capacity to recover quickly from shocks or disasters [13]. Organizational resilience, therefore, refers to the ability of firms to deal with unforeseen circumstances or respond and adapt to incremental changes and sudden economic and social disruptions.

According to the Brundtland Commission Report cited in [14], sustainable development refers to the "development that meets the needs of the current generation without compromising the ability of future generations to meets their own needs." The needs of the present generation could be social, economic, and technological [11]. These needs focus on improving the standard of living of the people, so any attempt to improve the standard of living without damaging the ecosystems or causing environmental degradation, including deforestation, water, and air pollution, climate change, and extinction of species, is referred to as sustainable development. Furthermore, sustainable development is an essential factor that has received considerable attention in the global development policy and agenda [15]. This is because it explains how society interacts with the environment without risking the survival of the future generations.

3. Digital Innovations/Industry 4.0 Technologies Adopted in Different Sectors of the Nigerian Economy and Its Impact on Organizational Resilience, Inclusion, and Sustainable Development

The Nigerian economy is one of the largest economies in Africa with several sectors, including the financial industry, health sector, agricultural sector, educational sector, transportation sector, construction sector, manufacturing or industrial sector, e-commerce sector, and the oil and gas sector, among others. The country is highly endowed with natural resources and has the largest natural gas reserves in the African continent. Nigeria has about 200 million people, with an average age of 18 years, making it a country with one of the youngest populations on earth [16]. With respect to geographical location, Nigeria is located between the central and western parts of Africa. It shares a border with Niger

in the north, Chad and Cameroon in the east, Gulf of Guinea of the Atlantic Ocean in the south, and Benin in the west. Therefore, the country has gained a reputation for offering access to those that reside in Western and Central Africa, representing over half of the African continent.

Industry 4.0 technologies transform every aspect of life, both in developed and developing countries, including Nigeria. As of 2020, the contribution of the Information and Communications Technology sector to the Nigerian Gross Domestic Product (GDP) stood at 17.83%, which is highly impressive when compared to the 13.85% contribution to the GDP in 2019 [16]. In Nigeria, the contribution of digital technologies to economic transformation is growing every day. Digital innovations, such as virtual reality, have enabled Nigerians to transport to other parts of the world, interact with information in new ways, and consume goods and services that are not produced within the country. In addition, it has helped professionals, such as medical doctors, to diagnose patients, lawyers to handle legal proceedings, and lecturers to attend international conferences, among others. Furthermore, digital innovations have contributed enormously towards the reduction in the poverty level. They also enhance inclusion, help organizations resist shocks and global disasters, reduce maternal and infant mortality, and promote sustainable farming and decent work. Digital innovations equally help in achieving universal literacy, which forms part of the sustainable development goals. A brief description of how digital innovations/industry 4.0 technologies are used in different sectors of the Nigerian economy to promote resilience, enhance inclusiveness, and support sustainable development is provided below.

3.1. Agricultural Sector

The emergence of industry 4.0 technologies has contributed tremendously to the agricultural sector's transformation in recent times. Digital technologies, such as AI, IoT, blockchain, drone technology, and cloud data solutions, among others, have been used to transform the agriculture sector and support sustainable development in Nigeria. For instance, the BeatDrone firm uses drone technology to monitor and eliminate the death of crops, map farmlands, and collect essential agrodata. The drone technology sprays herbicides and pesticides to kill weeds and pests, respectively. In contrast, the thermal drone helps farmers examine the farmland's temperature and determine the appropriate time to irrigate the farmland. Furthermore, the drone technology uses data pooling and AI, such as near-infrared devices, to gather data on a farm's chlorophyll levels, which helps the farmers to know the health status of crops, apply the necessary precautions or cure, save crops' lives and increase farm yields [17]. These technologies also help farmers to build resilience against potential attacks.

Furthermore, the same blockchain, IoT, and AI technologies have also been used to uplift the performance of the agricultural sector in Nigeria. For instance, Hello Tractor, Thrive Agric, Farmcrowdy, Crop2Cash, TradeBuza, Verdant AgriTech, AFEX, and AgroMall have contributed immensely to the agricultural sector development in Nigeria. Hello Tractor is an IoT digital solutions platform that connects financial institutions, farm equipment owners, and dealers, especially tractor owners, to farmers in Nigeria. This IoT platform digitalizes the tractor services and helps poor farmers that rely on crude agricultural technology with low financial resources (which often result in under cultivation and late planting) improve their farming activities, and hence their productivity and income. Hello Tractor promotes inclusion by connecting small and poor farm owners that often rely on traditional farming methods to the tractor owners to improve their farm yields. Specifically, the digital solutions firm helps farms access financial resources by connecting farmers to financial institutions, thereby supporting financial inclusion. Furthermore, the platform helps farmers and tractor owners to build resilience by using data pooling and AI to collect data on farmers' activities and provide remote tracking of farm equipment to prevent loss, fraud, and machine misuse. These promote sustainable development, especially sustainable farming and decent work in Nigeria. Some other technology-driven firms have also digitalized agricultural activities in Nigeria and have driven inclusive

economic growth and sustainable development to an extent. These include Farmcrowdy, Thrive Agric, AgroMall, Crop2Cash, and Afex [17].

Likewise, digital platforms, such as YouTube and Zoom, have largely been used to build resilience against global pandemics, such as COVID-19, which called for social distancing and minimizing conversational communication costs in the agricultural sector. The two platforms have been mainly used to train both large and smallholder farmers on new farming techniques in Nigeria. Moreover, they have served as a means of communicating essential information and updating farmers' knowledge on the digital marketing strategies that will boost their income. Furthermore, social media platforms, including Facebook and Twitter, have boosted agribusiness by allowing agricultural marketers to reach consumers of farm products and producers of agricultural inputs effectively and engage them in commercial transactions. In precis, by connecting the smallholder farmers to the global market, digital technologies promote inclusion and support sustainable development.

3.2. Health Sector

The health sector is crucial in any economy because the quality of the healthcare centers in a nation determines the quality of life of the people. Evidently, the Nigerian digital health system is still at the infancy stage, begging for attention [18]. In Nigeria, data pooling and AI are used in a few hospitals to track and diagnose health issues and perform day-to-day activities, including record keeping and payment of bills. In response to the COVID-19 pandemic in Nigeria, Mairabot and mobile health information tools were developed to fight coronavirus and communicate the symptoms, transmission channels, and prevention measures to Nigerians. A digital platform, such as Whatsapp, was also used to update Nigerians on the state of the pandemic, including the number of confirmed cases, deaths, recovered and new cases in the country [19]. Furthermore, the digital translation of COVID-19 symptoms, precautions, and guidelines into several languages helps to reach over 98% of Nigerians. This promotes inclusiveness and strengthens the country against the COVID-19 pandemic. A few health start-ups, such as GeroCare, InStrat Global Health Solutions, LifeBank, AirBank, Omoni, Find-a-med, GenRx 54gene, WellaHealth, Otrac, and Truppr, have digitalized the operations of the health sector in Nigeria. For instance, GeroCare, a cloud-based primary healthcare center, leverages IoT and blockchain to promote inclusiveness and build resilience against attacks on the aging population, by providing healthcare services to elderly patients at the comfort of their homes in Nigeria.

InStrat Global Health Solutions utilized digital technologies, including AI, IoT, and blockchain, to transform and improve Nigeria's health service delivery. In 2020, when COVID-19 was a burden across the globe, InStrat helped to build resilience against the pandemic by developing and launching the Android COVID-19 App, through which they communicate accurate information on the pandemic to the health workers in Nigeria. The application also helps over 20,000 front-line health workers identify, screen, and manage suspected cases in Nigeria [20]. InStrat promotes inclusion in the health sector by leveraging satellite technologies, including Inmarsat and NigComSat. In addition, the firm utilized digital technologies to develop an effective and efficient electronic health data management, also known as the Clinical Administration Kit, to help health workers both in the rural and urban areas capture patients' medical histories and treatment options and disseminate them through available mobile or satellite internet networks. This allows the Nigerian health centers to build resilience against internal and external attacks. Furthermore, LifeBank leverages digital technology to develop a blockchain-powered blood system that enables patients and health professionals to access blood and study the safety records of blood and blood products. Others include AirBank, which utilizes disruptive technologies to provide emergency medical oxygen delivery services; Omoni offers digital solutions that help parents to monitor the health of their children and Otracenables health workers enhance their clinical knowledge and performance with relevant training and courses through an e-learning platform [18].

3.3. Financial or Banking Sector

Digital technologies play an essential role in the financial sector across the world. The prominent digital technologies used in the financial sector are IoT, AI, blockchain, cloud computing, big data analytics, and robots [21]. In Nigeria, the rise of financial technology companies, commonly referred to as FinTech companies, has transformed the banking services landscape over the past few years. Digital innovations, such as chatbots, blockchain, WhatsApp, digital banking, mobile lending and savings, peer-to-peer lending platforms, crowdfunding, and point of sale (POS) terminals, have transformed the activities of the Nigerian financial sector [22,23]. These innovations have helped the sector to build resilience against the COVID-19 pandemic and also kept the country on the path of sustainable development. In addition, digital innovations increase financial inclusion by promoting financial service delivery in rural areas where larger populations are unbanked. Moreover, the adoption of disruptive technologies gives birth to the digital database for identification, eases the customers' onboarding process, and promotes access to credit for small and medium-sized enterprises (SMEs) [22]. In Nigeria, fintech companies, such as Piggyvest, Cowrywise, Kuda Bank, Bench, Renmoney, Fairmoney, Paylater, Quickteller, and Carbon, among others, have digitalized financial services. These digital financial platforms have helped to improve financial inclusion and increased SMEs' access to credit in Nigeria.

3.4. Educational Sector

Globally, digital technologies have changed the operations of the educational sector. Digital and distance learning have opened up programs to students who would have otherwise been deprived of education, especially in developing countries. In Nigeria, however, the use of digital technologies is still at a low ebb, possibly due to the poor digital infrastructure, inadequate funding of the educational sector, limited expertise, resistance to change by the educational sector, overdependence of the educational institutions on the government and disconnection among the various digital learning enhancement initiatives [24]. The report of the Economist Intelligence Unit Limited, which ranks the ability of a nation to leverage information and communication technologies to promote a digital learning environment, revealed that Nigeria ranks 79th out of the 81 countries in 2018, with a digital readiness score of 2.125 [25]. This simply suggests that the Nigerian educational sector lags in the adoption of the digital learning system. Despite the digital backwardness of the educational sector, there are still a few notable efforts to promote a digital learning environment in the country. For instance, the National Open University Nigeria (NOUN), the most recognized distance learning institution in Nigeria, is changing the modus operandi of the Nigerian universities. Unlike the conventional universities, NOUN delivers lectures virtually through a combination of Web-based modules, including audio, videotapes, and textual materials [26]. This makes it possible for students who would have been excluded to have access to education in Nigeria. Digital learning also helps the institution to be resilient, especially during the COVID-19 pandemic. In response to the challenges posed by the COVID-19 pandemic, a digital education company, commonly known as uLesson, leveraged digital technologies to create a virtual learning environment for students, most notably primary and secondary school students in Nigeria. This has greatly changed how primary and secondary school students learn and study for their examinations in the country and has made them resilient against internal and external attacks that may disrupt their studies. The implementation of computer-based tests by the joint admission and matriculation board has also helped advance the use of digital technologies in the Nigerian educational sector and these methods are being implemented in major universities today.

3.5. Transportation Sector

Digital firms are seriously challenging the existing practices in the Nigerian transportation sector. For example, E-transport companies, such as Nairaxi, Uber, OPay, Lara

Transport, and Kobo360, rely on the power of technology to digitalize transport services in Nigeria, and hence build resilience against shocks, improve inclusion, and put Nigeria on the path of sustainable development. For instance, Nairaxi utilizes disruptive technologies, such as blockchain, AI, and IoT, to build a multi-service platform and digital payment technology that make it possible for people to order a ride service at an affordable rate. The digital platform also has a feature that allows people to shop, track and have groceries and other items delivered to them at the comfort of their homes. The firms that render similar services in the transportation sector include Uber, Taxify, and OPay.

On the other hand, Lara Transport is an AI chatbot that has helped ease people's movement in Lagos State, Nigeria. This chatbot provides critical information, such as step-by-step directions, fare estimations, and alternative means of transportation from one place to another. Furthermore, Kobo360 is another digital transportation firm that has transformed the transportation services in Nigeria. Kobo360 leverages big data and other technologies to build a formidable logistic platform that deals with logistic frictions, thereby reducing transportation costs in the supply chain. The logistic platform helps achieve an inclusive, sustainable, and efficient supply chain by connecting cargo owners, truck owners, drivers, and cargo recipients. Specifically, the firm enables farmers to increase their earnings by reducing agricultural wastages and helping manufacturers to expand their market share [27]. During the COVID-19 pandemic, when the Nigerian government put several measures in place to control the spread of the coronavirus, Kobo360 became a household name, as it helped to build resilience against the pandemic.

3.6. E-Commerce Sector

Digital technologies remain the driving force of sustainable development in the e-commerce industry worldwide, and the e-commerce industry is perhaps the most digitalized sector in Nigeria. In Africa, disruptive technologies are used to eliminate trade restrictions and stabilize the trading system. Digital companies, such as Jumia, Konga, Mall for Africa, Olx, and Jiji, have extremely changed the boundaries for marketers and consumers as they allow marketers or sellers to market their goods; and consumers to order items and get them delivered cheaply and quickly without any stress [28]. During the COVID-19 pandemic, these e-commerce firms were largely used to facilitate trade, and hence the e-commerce sector's resilience. The platforms also promote inclusiveness by extending their services to the underserved communities to support sustainable development in Nigeria.

4. The Nigeria Digital Economy Policy/Strategy and Challenges of Industry 4.0 Adoption in Nigeria

The Nigerian government has made several efforts to digitalize the Nigerian economy. These include the digitization of key activities, such as the use of the Bank Verification Number (BVN), virtual conferences and meetings, Treasury Single Account (TSA) and the Integrated Payroll and Personnel Information System (IPPIS), SIM registration, and data registration exercise for the National Identity Number. Digitalizing the key activities, most notably BVN, virtual conferences and meetings, and TSA, has enabled the government to save cost, fight corruption, and trail the path of sustainable development. In addition, it has led to an improvement in the citizens' participation in key activities and helped the country to build resilience against internal and external attacks. Recently, the Nigerian government reprogramed the Federal Ministry of Communications as the Federal Ministry of Communications and Digital Economy and charged it with the responsibility of developing and implementing effective digital economic policies and strategies that will fast-track the digitalization of the Nigerian economy [16]. Several factors have been identified as hindrances to the adoption of digital and industry 4.0 technologies in Nigeria. These factors are affordability, illiteracy/language barrier, disparities between urban and rural areas, lack of digital literacy, internet crime or computer phobia, fluctuating transmission signal, and institutional factors [11,29]. To promote the use of digital technologies and minimize the

possible effect of future global problems on the Nigerian economy, the government and leaders of industries must work together and address the factors hindering the adoption of industry 4.0 technologies in Nigeria.

5. Conclusions

This study investigates the roles of digital technologies in promoting inclusion, resilience, and sustainable development in Nigeria, especially during and after the COVID-19 pandemic. First, an attempt is made to identify the various technologies adopted in the different economic sectors. Second, the study provides a clear explanation of how different actors use digital technologies to determine innovative and resilient approaches to combat unsustainable development, inequality, and economic backwardness in Nigeria. Based on the available evidence, the study concludes that the agriculture, e-commerce, financial, and transportation sectors majorly use digital technologies to promote inclusion, build resilience and support sustainable development in Nigeria. Therefore, the study recommends that the Nigerian government and leaders of industries should work together and address the factors hindering the adoption of industry 4.0 technologies in Nigeria to minimize the possible effects of future internal and external shocks on the Nigerian economy. Furthermore, the government must develop strategies to prevent brain drain and formulate policies that will encourage the upspring of digital firms in Nigeria. Finally, the government and leaders of industries should create an incentive system that will promote digital innovations for sustainable development.

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Developing Youth's Capacities as Active Partners in Achieving Sustainable Global Food Security through Education †

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Abstract: Eradicating extreme poverty and achieving food security is still one of the greatest challenges of our time. Attracting and retaining youth in the agricultural sector is critical for alleviating hunger and malnutrition. The present study hypothesized that the provision of formal agricultural education, whether through direct involvement in farming practices with an emphasis on environmental sustainability or in entrepreneurial work, increases rural youth's connection to their local environment, their perceptions of agriculture's impact on their local community, and their aspirations for a career in the agricultural sector. To test the hypothesis, 577 students from a high school in Cambodia took two questionnaires following their participation in formal agricultural education provided by a technology park. Factor and linear regression analyses were conducted, and significant results were observed, highlighting the benefits of providing age-appropriate programs that are designed to raise awareness and build capacities in the agricultural sector. The findings of this study contribute to the growing body of literature that seeks to guide future policies and training agendas to adopt effective approaches in engaging youth in productive, profitable, and sustainable agriculture as active partners in the sustainable development efforts to achieve inclusive and stable societies.

Keywords: youth; agricultural education; innovation; technology; food insecurity; capacity building; development

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1. Introduction

Despite progress in recent decades, eradicating extreme poverty and achieving food security remains one of the greatest challenges of our time. At the end of 2020, more than 155 million people were suffering from acute food insecurity [1], and Asia remains home to the greatest number of malnourished people [2]. Given rapid population growth, high rates of global consumption, climate shocks, rural stagnation, conflict, and the need for sustainable agricultural production, the number of people affected by food insecurity is projected to surpass 840 million by 2030 [3]. With the COVID-19 pandemic exacerbating the situation further, swift action must be taken to increase the capacity for sustainable food production and resilient agricultural practices to alleviate hunger and malnutrition [4]. However, the rising average age of farmers poses a challenge to achieving this goal.

Recognized as the torchbearers of the sustainable development agenda, active youth engagement in the agricultural sector has been at the heart of several development policies [5]. The potential benefits of involving today's youth in the struggle to increase

agricultural production include food security, poverty reduction, job creation, and political stability. In Cambodia, 52% of the total population was aged younger than 25 years old as of 2015 [6]. According to data from the International Labour Organization (ILO), more than 77% of them reside in rural areas. This is a potential demographic dividend that may lead to economic growth if the right measures are taken [6]. However, to reap the benefits of engaging young people in the agricultural sector, challenges such as the skills mismatch, high rates of youth internal migration from rural areas into urban centers [7], and their disinterest in agricultural-related occupations must be addressed.

The Cambodian economy has significantly grown over the past few years and is still expanding at a fast rate. The agricultural sector alone contributes to almost a quarter of its GDP [8]. However, the Cambodian youth employment to population ratio dropped from 78% in 2010 to 70.2% in 2019, according to the International Labour Organization. Moreover, while the share of youth in vulnerable employment has fallen dramatically among youth over the years, it still remains at a non-negligible 47%. The total share of youth not in education, employment, or training is relatively low; nonetheless, it increased from 0.2% in 2010 to 6.1% in 2017, according to the Household Socio-Economic Survey.

As a consequence, a large outflow of Cambodian youth work in neighboring countries, such as Thailand, Malaysia, Singapore, and Korea, in the agricultural, industrial, and construction fields [7]. Due to the mismatch between the required and provided skills, knowledge, and abilities, Cambodian youth migrants are forced to work as unskilled or low-skilled workforces [9]. In fact, youth in Cambodia only receive an average of 6.3 years of education with few opportunities to improve their skills [10], making them less competitive in the ASEAN Economic Community and more likely to be vulnerable to violence, abuse, drugs, and exploitation [11]. Key intervention strategies aimed at involving youth in the agriculture sector can significantly reduce the risks of them becoming further disadvantaged.

Given recent transformations in agricultural markets and supply chains and that global agricultural demand is projected to increase by 60% by 2050 [12], new opportunities for youth to run profitable agribusinesses in Cambodia are emerging [12]. Evidence indicates, however, that disinterest in agricultural-related occupations exists amongst Cambodian youth due to stereotypes that perceive farming as outdated, unprofitable, and hard work [13–16]. Timely interventions directed at increasing youth's interest in the sector and providing capacity-building programs to produce a qualified workforce are likely to yield a greater return for sustainable development.

With subsistence agriculture being the main income source for most of the country's rural population [17], Cambodia's reliance on agriculture leaves the country's economy vulnerable to climate shocks. In 2019, Cambodia was hit with a prolonged and severe drought that resulted in failed crops and affected its fish stocks [18]. The problem was further exacerbated by the coronavirus pandemic, resulting in the market's inability to satisfy the increasing demand for food. Moreover, agriculture is often responsible for local water pollution and is a primary contributor to global warming through unsustainable large-scale practices. These issues offer opportunities for innovative tools, technology, and practices to sustainably intensify production. The right information and training provide young farmers with the tools and information they need to maximize efficiency and productivity and minimize their carbon footprints in agriculture. For Cambodia to further increase its agricultural productivity without forfeiting too much soil or entering unsustainable debt levels, youth involvement is thus essential.

Despite recognizing the role youth can play in the development of the agricultural sector, limited attention has been given to their aspirations and trajectories related to the labor market [19]. In order for specialists in the field of sustainable agricultural development to understand shifts in intergenerational relations and to be able to offer age-specific solutions and incentives, research aimed at youth is needed [20]. Further, there is a need for thorough systematic evaluations of implemented educational and vocational programs that can help in identifying the barriers and enabling factors for particular contexts and groups.

Social cognitive career theory (SCCT), which was developed by Lent, Brown, and Hackett (1994), postulates that to cultivate interest in pursuing a given academic major, individuals must be first exposed to direct, vicarious, and persuasive experiences that foster efficacy beliefs and positive outcome expectations in school, at home, and/ or in their communities [21]. According to this theory, background contextual factors and learning experiences have an effect on self-efficacy and outcome expectations, which, in turn, influence interests in pursuing a particular educational and career path [21]. Drawing on the interest, choice, and performance models of SCCT, the present study hypothesized that the provision of formal agricultural education increases rural youth's connection to their local environment, their perceptions of agriculture's impact on their local community, and their aspirations for a career in the agricultural sector. Specifically, the study sought to answer the following questions:

RQ1. Does the provision of formal agricultural training, whether through direct involvement in farming practices with an emphasis on environmental sustainability or in entrepreneurial work, increase rural youth's connection to the local environment?

RQ2. Does this kind of provision of formal agricultural education change rural youth's perceptions of agriculture's impact on their local community?

RQ3. Does this kind of provision of formal agricultural education change rural youth's aspirations for a career in the agricultural sector?

2. Materials and Methods

Two questionnaires (pre- and post-surveys) were administered to 577 students at a school located at the Kampong Thom Center of Excellence on Sustainable Agricultural Intensification and Nutrition (CE SAIN) Agricultural Technology Park, approximately 30% of the school population. The Technology Park is an innovation hub that brings together researchers, industry, and local farmers in designing and implementing appropriate tools and practices for sustainable intensification. Questionnaire items were pulled from instruments from previous studies with similar purposes and were reviewed for language and cultural appropriateness by a CE SAIN staff member. Seven items from the validated Nature Relatedness Scale (2009) were used to assess students' connection to the local environment. Six items of a similar nature were pulled from the Douglas et al. (2017) and Luckey (2012) studies to gauge students' perception of the impact agriculture has on their local community, and five items to assess students' interest in farming as a career. Since there were no validated and context-appropriate instruments that assess youth's attitudes regarding farming and agriculture, the three scales were used in an exploratory manner, and only the items that were found to be suitable in the Cambodian context were used. The questionnaires contained 18 Likert-type items with five points ranging from 1 (disagree strongly) to 5 (agree strongly). The items were used to capture (a) changes in students' perceptions of their own connection to the local environment, (b) changes in students' perceptions of agriculture's impact on the local community; and (c) changes in students' perceptions of a career in the agricultural sector.

One thousand one hundred nine students were enrolled in the school when the study started in 2018, with 140 students in Grade 9, 420 in Grade 10, 339 in Grade 11, and 210 in Grade 12. The pre-survey was administered in November 2018 to 324 students (56% of the entire sample), of which 198 of the pre-survey respondents were female students (61%) and 125 were male students (39%). Respondents' ages ranged from 12 to 20 years (M = 16, SD = 1.6), where two students in Grade 9 were just 12 years of age, and five students in Grades 11 and 12 were 20. Grade 9 served as the baseline, as the students had no previous engagement with the Technology Park's activities at the time of the survey. Two hundred seventy-one of the pre-survey respondents (84%) indicated having participated in the Technology Park program's educational activities. A total of 253 students (44% of the entire sample) were recruited for the post-survey in January 2020. The post-survey was initially intended as a paired follow-up survey and, as such, did not collect demographic variables. However, due to graduation, dropouts, new enrollments, and the fact that participation was voluntary,

only 43% (n = 112; 37 female, 73 male) of the initial sample took the post-survey, and additional participants were recruited. In total, 235 of the post-survey respondents (93%) indicated having participated in the Technology Park program's activities. Frequencies and percentages for both surveys are presented in Table 1.

Table 1. Frequency table for the survey variables.

Variable	Level	Pre-Survey		Post-Survey	
		n	%	*n*	%
Gender	Female	198	61	–	–
	Male	125	39	–	–
Engagement with Park's activities	No	53	16	18	7
	Yes	271	84	235	93
Prior exposure to farming	No	113	35	76	30
	Yes	211	65	177	70
Grade	9	75	23	–	–
	10	119	37	63	25
	11	65	20	163	64
	12	65	20	27	11

3. Results

Descriptive statistics for the entire data set and the correlations among the items were examined (Appendix A, Table A1). Factor analysis was conducted using the Lavaan package version 0.6–7 in R software with Promax rotation to estimate the model parameters, as the factors were believed to be correlated. The Kaiser's eigenvalue-greater-than-one rule was applied to elect how many factors to retain for interpretation, and three factors were retained. Items were then averaged to create a score for the retained factors: environmental connection, agricultural impact, and farming career. Items and their loadings are summarized in Table 2.

Table 2. Questionnaires items and their standardized loadings.

Farming Career		Environmental Connection		Agricultural Impact	
Item	**Loadings**	**Item**	**Loadings**	**Item**	**Loadings**
I like to pursue agriculture as a career.	0.67	I am very aware of environmental issues.	0.49	Agriculture impacts me daily.	0.68
I want to own a farm business one day.	0. 83	I always think about how my actions affect the environment.	0.53	Agriculture is important to my community.	0.68
Farming provides skills for one to earn a living.	0. 51	My relationship to nature is an important part of who I am.	0.80	I feel that it is important for youth like me to learn about agriculture.	0.55
Farming generates enough income.	0. 63	I think a lot about the suffering of animals.	0.60	Shelter is a result of agricultural practices.	0.63
I would like to work in agriculture.	0.82	I feel very connected to all living things and the earth.	0.50	Food is a result of agricultural practices.	0.57
		My connection to nature and the environment is part of my spirituality.	0.72	Clothing is a result of agricultural practices.	0.46
		I am not separate from nature, but a part of nature.	0.82		

Likert scores of 4 or greater were regarded as positive student perceptions. Scores of 2 or lower were regarded as negative student perceptions, whereas scores between 2.5 and 3.5 were regarded as neutral. Frequencies of the responses for both surveys filtered based on engagement with the Technology Park's educational activities condition are summarized in Appendix B (Table A2). When respondents who participated in the activities were asked whether agriculture impacted them daily, 8% more positive responses were observed in the

post-survey. Meanwhile, 72% of the post-survey respondents indicated that they want to own a farm business one day, which is an 8% increase in the positive responses from the pre-survey (64%). Participation in the Park's activities also resulted in positive changes in students' perception of the sector's profitability. Ninety-six percent (96%) of post-survey respondents indicated that farming provides skills for one to earn a living compared with 92% in the pre-survey. Similarly, the post-survey responses to the statement "farming generates enough income" were 5% more positive compared with pre-survey responses.

Linear regression analyses were conducted to assess whether engagement with the Park's activities significantly predicted farming career, environmental connection, and agricultural impact, with prior exposure to farming and grade as covariates to control for their potential confounding effects. Participants reported on the question "we practice farming at home" as a measure of prior exposure to farming. The results for both surveys are discussed next.

3.1. Research Question 1 (RQ1)

The results of the linear regression model for the pre-survey were significant, $F(3,320) = 10.22$, $p < 0.001$, $R^2 = 0.09$, accounting for approximately 9% of the variance in students' environmental connection as explained by prior exposure to farming, grade, and engagement with the Park's activities. In this analysis, prior exposure to farming was nonsignificant (Table 3). Grade significantly predicted environmental connection, as did engagement with the Park's activities. The results for the post-survey were significant as well, $F(3,249) = 11.88$, $p < 0.001$, $R^2 = 0.13$, indicating that approximately 13% of the variance in environmental connection is explained by the same variables. Prior exposure to farming and engagement with the Park's activities were significant predictors. Unlike the pre-survey, grade did not significantly predict environmental connection.

Table 3. Results for linear regression with prior exposure, grade, and engagement predicting environmental connection, agricultural impact, and farming career.

RQ #	Survey	Variable	*B*	*SE*	95% CI	β	*t*	*p*
RQ1	Pre	(Intercept)	19.71	1.86	(16.05, 23.37)	0.00	10.59	0.001
		Prior exposure (yes)	0.75	0.50	(−0.24, 1.73)	0.08	1.49	0.137
		Grade	0.54	0.19	(0.18, 0.91)	0.16	2.92	0.004
		Engagement (yes)	1.62	0.53	(0.57, 2.66)	0.17	3.04	0.003
	Post	(Intercept)	16.05	3.88	(8.40, 23.69)	0.00	4.14	0.001
		Prior exposure (yes)	1.49	0.61	(0.29, 2.69)	0.15	2.44	0.015
		Grade	0.62	0.35	(−0.06, 1.31)	0.11	1.79	0.075
		Engagement (yes)	3.87	0.79	(2.32, 5.42)	0.29	4.92	0.001
RQ2	Pre	(Intercept)	13.53	1.80	(9.99, 17.08)	0.00	7.51	0.001
		Prior exposure (yes)	1.44	0.49	(0.49, 2.40)	0.16	2.97	0.003
		Grade	0.52	0.18	(0.17, 0.87)	0.16	2.90	0.004
		Engagement (yes)	2.19	0.51	(1.18, 3.20)	0.23	4.27	0.001
	Post	(Intercept)	13.65	3.59	(6.58, 20.71)	0.00	3.81	0.001
		Prior exposure (yes)	2.03	0.56	(0.92, 3.14)	0.22	3.61	0.001
		Grade	0.53	0.32	(−0.11, 1.16)	0.10	1.64	0.102
		Engagement (yes)	1.52	0.73	(0.09, 2.95)	0.13	2.09	0.037
RQ3	Pre	(Intercept)	10.68	1.71	(7.32, 14.04)	0.00	6.25	0.001
		Prior exposure (yes)	1.38	0.46	(0.47, 2.29)	0.16	3.00	0.003
		Grade	0.54	0.17	(0.21, 0.88)	0.18	3.20	0.002
		Engagement (yes)	1.38	0.49	(0.42, 2.34)	0.16	2.84	0.005
	Post	(Intercept)	11.11	3.12	(4.97, 17.26)	0.00	3.56	0.001
		Prior exposure (yes)	1.86	0.49	(0.90, 2.82)	0.23	3.80	0.001
		Grade	0.47	0.28	(−0.08, 1.02)	0.10	1.68	0.094
		Engagement (yes)	1.46	0.63	(0.21, 2.71)	0.14	2.31	0.022

3.2. Research Question 2 (RQ2)

The results of the linear regression model for the pre-survey were significant for agricultural impact, $F(3,320) = 18.05$, $p < 0.001$, $R^2 = 0.14$, accounting 14% of the variance. Prior exposure significantly predicted students' perceptions of agriculture's impact on their local community (Table 3). Grade and engagement with the Park's activities also significantly predicted agricultural impact. Similar to the pre-survey, the results for the post-survey were significant, $F(3,249) = 7.13$, $p < 0.001$, $R^2 = 0.08$, indicating that approximately 8% of the variance in agricultural impact is explainable by the variables. Both prior exposure and engagement significantly predicted agricultural impact. Grade, however, was nonsignificant.

3.3. Research Question 3 (RQ3)

The results of the linear regression model for the pre-survey were significant, $F(3,320) = 13.80$, $p < 0.001$, $R^2 = 0.11$, indicating that 11% of the variance in students' attitude toward a career in farming is explained by the variables. Both prior exposure and grade significantly predicted students' attitudes toward a career in farming. Engagement in the Park's activities was a significant predictor as well. The results of the linear regression model were also significant for the post-survey, $F(3,249) = 8.03$, $p < 0.001$, $R^2 = 0.09$, accounting for approximately 9% of the variance in students' attitudes toward a career in farming. The results indicate that having prior exposure to farming and engaging in the Park's activities significantly predict a career in farming. Grade, however, was nonsignificant. Table 3 summarizes the results of the regression models for both surveys.

4. Discussion

4.1. Sustainable Agriculture

Linear regression analyses of the pre- and post-surveys suggest that the provision of agricultural education at school around topics of sustainable agriculture, as well as prior experience with farming, can positively affect students' connection to their local environment. Grade was a predictor of higher environmental connection in the pre-survey, which included students in Grade 9 who had no previous engagement with the Technology Park's activities at the time of the survey. In the post-survey, when students in Grades 10–12 were surveyed 1 year later, grade was not a predictor of higher environmental connection. This provides support for the view that involving youth in educational programs that promote the adoption of sustainable agricultural technologies and practices can strengthen their connection with the local environment, such that after 1 year of schooling, there was not a significant difference between Grade 9 students and the upperclassmen. The results, consistent with prior studies conducted in similar contexts, suggest that youth involvement is essential to further increase global agricultural productivity.

4.2. Agricultural Impact

The Technology Park's educational activities had a significant effect on youths' perceptions of the impact that agriculture has on their local community. Participants' responses were significantly different between the pre- and post-questionnaires, as shown in Appendix B. Compared with the pre-survey, more participants in the post-survey understood that food is a direct result of agricultural practices, and that agriculture has an impact on their daily life. This was further confirmed by the results obtained from the regression analyses for both surveys, which indicated that the Park's activities, coupled with prior experience in farming, significantly improved young participants' perception of agriculture's impact. There were also no differences observed between Grade 9 students and the upperclassmen a year later. This again indicates that the provision of this type of education can significantly improve youths' perception and understanding of the impact agriculture has on the local community. These results are consistent with SCCT in that it is more likely for a person to engage in an activity if they believe it will lead to valuable

and positive results. To retain and attract youth in the sector, youth need to see farming as useful and understand the impact that it has on their local community.

4.3. Farming Career

One of the most significant outcomes of the Technology Park's program is that students were left with an improved perception of the agribusiness opportunities within the sector. The regression analyses of both surveys indicate that participants' engagement with the Technology Park's activities, along with prior exposure to farming, had a positive effect on their attitudes toward a career in farming. While grade was a significant predictor of farming career in the pre-survey, no significant difference between Grade 9 students and the rest of the students was observed in the post-survey. This follows the previous analyses and suggests that engagement with agricultural educational experiences positively changed students' perceptions about farming and a future career in agriculture. The results are consistent with SCCT in that youth tend to pursue a career that they perceive as profitable. As modern knowledge and skills are the basis of any future workforce, Cambodian youth need to be provided with a range of agricultural, financial, and entrepreneurial skills and knowledge through youth-targeted policies and investments.

The results further reinforce the notion that youth are, and should be, recognized as an integral part of the solution to food security. Stakeholder investment in education that engages young people in sustainable and production methods, and provides opportunities for greater market engagement and innovation, may help youth consider agriculture as a career option [12]. To precipitate interest toward agriculture, a broader change in a young person's experiences and changes at national and international levels are required. Given the demographic diversity of youth, both urban and rural youth should be involved as partners in decision-making at local and national levels.

5. Conclusions

The Cambodian agricultural sector provides a significant source of income and employs one-third of the national workforce. However, the rising average age of farmers and Cambodian youths' disinterest in agricultural-related occupations necessitate youth-targeted interventions. Grounded in SCCT, the present study sought to explore whether the provision of formal agricultural education significantly predicted youths' connection to their local environment, their attitudes toward the impact agriculture has on their local community, and their aspirations for a career in the agricultural sector. Linear regression analyses were conducted, and significant results were observed, indicating that engagement with agricultural education and practices positively influenced youths' interest in farming. The results highlight the benefits of providing age-appropriate programs that are designed to raise awareness and build capacities in the agricultural sector. Such programs are crucial for the inclusive and sustainable adoption of new technologies and access to markets. It is hoped that the results of this study can contribute to the growing body of literature that seeks to guide future policies and training agendas to adopt effective approaches in engaging youth in productive, profitable, and sustainable agriculture as active partners in the sustainable development efforts to achieve inclusive and stable societies.

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Institutional Review Board Statement: The study was conducted according to the guidelines of the Declaration of Helsinki and approved by the Institutional Review Board of The University of Illinois Urbana-Champaign (protocol code 17844, 13 July 2018).

Informed Consent Statement: Informed consent was obtained from all subjects involved in the study.

Data Availability Statement: Deidentified data that support the findings of this study are available from the corresponding author, GA, upon reasonable request.

Conflicts of Interest: The authors declare no conflict of interest.

Appendix A

Table A1. Means, standard deviations, and correlations with confidence intervals.

Variable	*M*	*SD*	1	2	3	4	5	6
1. Survey	0.44	0.5						
2. Grade	10.58	0.91	0.27 ** [0.19, 0.34]					
3. Farming Career	13.92	2.92	0.11 ** [0.03, 0.19]	0.21 ** [0.13, 0.29]				
4. Environmental Connection	21.46	3.62	0.12 ** [0.04, 0.20]	0.25 ** [0.17, 0.32]	0.59 ** [0.53, 0.64]			
5. Agricultural Impact	19.96	2.4	0.01 [−0.07, 0.09]	0.19 ** [0.11, 0.27]	0.64** [0.59, 0.69]	0.58 ** [0.53, 0.64]		
6. Engagement with Park's Activities	0.79	0.41	0.30 ** [0.22, 0.37]	0.57 ** [0.51, 0.62]	0.24 ** [0.17, 0.32]	0.25 ** [0.17, 0.32]	0.24 ** [0.16, 0.31]	
7. Prior Exposure to Farming	0.85	0.36	0.06 [−0.02, 0.14]	0.10 * [0.02, 0.18]	0.25 ** [0.17, 0.33]	0.28 ** [0.20, 0.35]	0.20 ** [0.12, 0.27]	0.15 ** [0.07, 0.23]

Note. M and *SD* are used to represent mean and standard deviation, respectively. Values in square brackets indicate the 95% confidence interval for each correlation. * Indicates $p < 0.05$. ** Indicates $p < 0.01$.

Appendix B

Table A2. Frequencies for response items filtered by treatment condition.

	Condition	No Engagement			Engagement		
	Response	Negative	Neutral	Positive	Negative	Neutral	Positive
Pre-Survey	I like to pursue agriculture as a career.	16	23	14	46	67	158
	I want to own a farm business one day.	12	19	22	50	47	174
	Farming provides skills for one to earn a living.	6	6	41	8	15	248
	Farming generates enough income.	5	10	38	16	27	228
	I would like to work in agriculture.	12	19	22	37	57	177
	I am very aware of environmental issues.	17	9	27	35	37	199
	I always think about how my actions affect the environment.	6	4	43	18	9	244
	My relationship to nature is an important part of who I am.	3	8	42	12	14	245
	I think a lot about the suffering of animals.	10	8	35	37	31	203
	I feel very connected to all living things and the earth.	12	15	26	34	42	195
	My connection to nature and the environment is part of my spirituality.	12	19	31	17	21	233
	I am not separate from nature, but a part of nature.	2	2	49	7	3	261
	Agriculture impacts me daily.	24	19	10	56	45	170
	Agriculture is important to my community.	4	6	43	5	16	250
	I feel that it is important for youth like me to learn about agriculture.	7	11	35	17	24	230
	Shelter is a result of agricultural practices.	18	14	21	50	68	153
	Food is a result of agricultural practices.	5	4	44	15	22	234
	Clothing is a result of agricultural practices.	33	6	14	83	40	148

Table A2. *Cont.*

	Condition	No Engagement			Engagement		
	Response	**Negative**	**Neutral**	**Positive**	**Negative**	**Neutral**	**Positive**
Post-Survey	I like to pursue agriculture as a career.	7	5	6	22	69	69
	I want to own a farm business one day.	6	2	10	15	50	50
	Farming provides skills for one to earn a living.	0	4	14	3	6	6
	Farming generates enough income.	0	2	16	9	17	17
	I would like to work in agriculture.	5	5	8	20	59	59
	I am very aware of environmental issues.	7	3	8	22	33	33
	I always think about how my actions affect the environment.	3	1	14	6	10	10
	My relationship to nature is an important part of who I am.	5	4	9	4	16	16
	I think a lot about the suffering of animals.	7	3	8	16	33	33
	I feel very connected to all living things and the earth.	4	7	7	28	51	51
	My connection to nature and the environment is part of my spirituality.	5	2	11	7	19	19
	I am not separate from nature, but a part of nature.	4	1	13	1	11	11
	Agriculture impacts me daily.	5	4	9	23	45	45
	Agriculture is important to my community.	2	3	13	12	17	17
	I feel that it is important for youth like me to learn about agriculture.	3	4	11	7	27	27
	Shelter is a result of agricultural practices.	3	4	11	33	51	51
	Food is a result of agricultural practices.	3	2	13	8	13	13
	Clothing is a result of agricultural practices.	4	8	6	71	46	46

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Proceeding Paper

Sustainable Innovation as a Driver for Socio-Ecological Transition †

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Abstract: Societies are facing major and worsening environmental, social and health crises. In order to deal with these challenges, a major socio-ecological transformation is required. Sustainable innovation (SI) is one of the means to achieve this goal. We propose in this article a new definition of SI for sustainable development purposes, guided by the SDGs and setting the context, along with comprehensive literature. The article then highlights the concepts to which SI is related, such as the theory of sociotechnical systems and transitions, as well as its fields of application, such as the circular economy, regenerative design and transformative social innovation.

Keywords: sociotechnical approach; socio-ecological transition; sustainable development; sustainable development goals; circular economy; regenerative design; transformative social innovation

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1. Introduction

Governments and people are facing significant economic, social and environmental challenges. In this era of globalization and a context of a growth-based industrial society model, human activities are exceeding the sustainability thresholds supported by the biosphere [1].

The socioeconomic picture is as worrisome as the environmental one, with increasing wealth and inequality at the national and international levels, and growing disparities in resource use [2]. There are also disparities in the attribution of the environmental impacts [3].

Similarly, while the COVID-19 pandemic has profoundly disrupted communities, large differences have been observed across countries, particularly regarding the uneven distribution of vaccines that threaten the possibility of global herd immunity. The health crisis heavily impacted the populations: a large number of contaminations, deaths and people with long-term effects, upheavals in several sectors of activity, precariousness of employees and organizations, public indebtedness and amplification of social inequalities. The pandemic has also highlighted the links between human activities and environmental degradation since the destruction of ecosystems increases the risks of propagation of zoonoses [4].

These observations show the interrelations between, on one hand, human activities that are harmful to the environment and cause social inequalities, and on the other hand, the pandemic crisis. This situation calls for profound changes in our interpretation of socioeconomic recovery in order to promote more resilient and sustainable models. This "socio-ecological" transition requires, among other things, a dematerialization and decarbonization of the economy, as well as a more just distribution of resources [5].

However, the societal transformations that are required are inhibited or complicated by the evolving and multidimensional nature of societies and the environment, by the interactions between society and nature as well as by societal lock-ins that inhibit the implementation of a socio-ecological transition. Crises also influence our lifestyles in both the short and long term, and they therefore offer opportunities to foster change.

On another level, we can observe the emergence of environmental and social innovations in several sectors of activity. This underlying trend is a trigger of the general context we called "**sustainable innovations**" (**SI**), which can be considered as a powerful tool for accelerating the movement towards sustainability (Figure 1). Indeed, SI could be a key tool for aligning the economy with social, environmental and health constraints. The current conjuncture thus seems opportune to develop a real inter-sectoral and interdisciplinary community of SI.

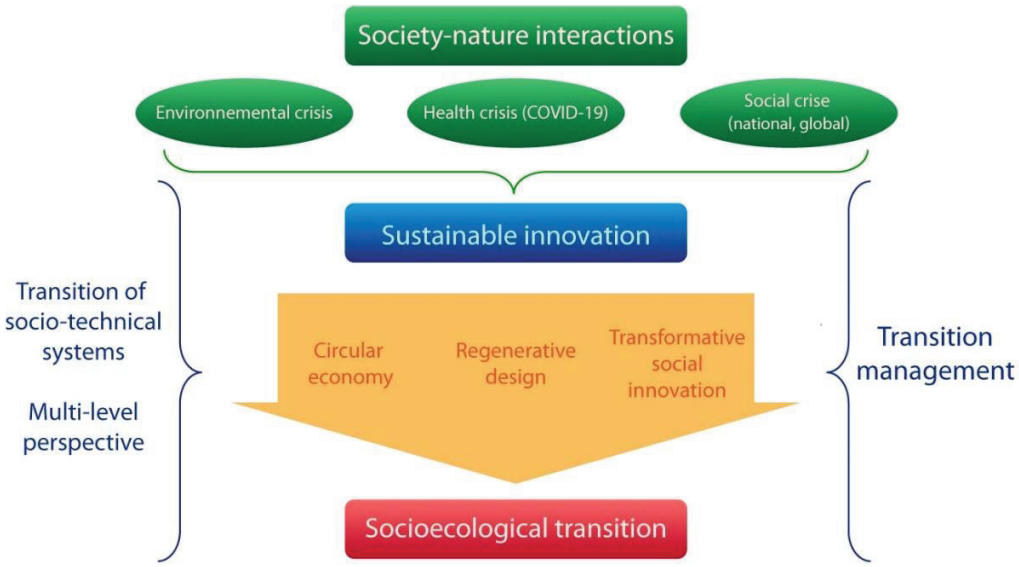

Figure 1. The role of sustainable innovations (SI) in the socio-ecological transition and its environmental, social and health context. The figure shows the application fields of SI (circular economy, regenerative design and transformative social innovation) as well as research domains that may make its implementation successful (i.e., transition of sociotechnical systems, multi-level perspective and transition management).

However, this concept is still in its infancy, both within research and teaching institutions, and among field actors. There are still unclear areas regarding its definition and operationalization. It also has to be supported by academic research in the field of transition theory and complex systems such as modern societies, and by stakeholders.

In order to present the potential benefits of SI in the implementation of sustainable development (SD) and the achievement of the Sustainable Development Goals (SDGs), and to contribute to unify the research community and practitioners around a common and consolidated understanding of SI, this article presents a literature review on SI from an inter-trans/disciplinary perspective, as illustrated in Figure 1.

The origins of this concept, and the context in which it is embedded, are first presented. This work then highlights the fundamental research fields to which SI is linked, namely the theory of transitions of sociotechnical systems, in particular with the support of the multi-level perspective and the transition management. The article then presents the fields of application of SI, including the circular economy, regenerative design and transformative social innovation. The article then sums things up in a brief conclusion.

2. Origins and Definition of Sustainable Innovation (SI)

The aim of this section is to provide a brief portrait of the types of innovations that have preceded and may be associated with SI. Based on the benefits, characteristics and objectives of these innovations, while incorporating the imperatives of the Introduction section, a definition of SI is then proposed.

2.1. Origins and Context

The mainstream of innovation in the 20th century was essentially techno-centric and focused on economic value creation. However, over the past two decades, the acceleration of global crises and the growing popularity of systems approaches to socioeconomic issues have led to an increased focus on social innovation. Social innovation considers the challenges of socioeconomic inequalities and focuses on improving the collective well-being and the capacity to act of individuals and social groups [6]. It is a mobilizing innovation that promotes inclusion, modifies social relations and reinforces the autonomy of individuals.

Another trend is represented by eco-innovations, defined as having a reduced environmental burden (reduced resource or energy use, low-carbon materials and processes, quality and sustainability, etc.). Eco-innovations are often focused on high technologies such as renewable energies, geoengineering or biotechnology, and are often implemented on a large scale. While these innovations can contribute to minimizing the impact of societies, they can sometimes increase consumption by the rebound effect. Above all, they do not challenge an economic model that fails to respect planetary limits or social constraints.

In contrast to eco-innovations, the societal landscape has been giving way in recent decades to grassroots innovations such as urban farms, the use of local currencies, microcredit and other social or community innovations. These solutions are notably illustrated by frugal innovation, also known as Jugaad innovation, which comes from developing countries such as India. This type of innovation, born from economic constraints, ingenuity, and individual and collective field experience, aims primarily at meeting the needs of the population by offering effective solutions, at lower cost and developed from local resources [7].

In the same family are the retro-innovations, popular in particular in the field of agroecology. This type of innovation implies a certain return to pre-existing or ancestral practices, supported by modern knowledge, which requires fewer resources, less investment, and guarantees a higher level of quality with high yields [8]. This type of innovation is the object of little interest from research teams to evaluate their sustainability, which ends up confining them, as well as frugal innovations, to a still marginal sphere. Yet they constitute a rich pool of SI.

Born from the observation of the disconnection between, on the one hand, the global scale of eco-innovations mainly focused on technology, and on the other hand, the local scale of social and community innovations, a new type of innovation that is oriented towards transformation has emerged under the terms mission-oriented and transformative innovations that aim a deep societal change [9,10]. The major challenge of SI lies in its capacity to go beyond top-down policies focused on technologies, since current policies are insufficient to limit environmental degradation and meet social needs. Thus, in order to achieve a radical systemic transformation, not only global, but also multi-scale coordination must be oriented towards common goals.

Open innovation represents an opportunity to bring together the various stakeholders. This type of innovation aims at sharing knowledge, information and best practices within the innovation ecosystem and even beyond [11,12]. With the increasing complexity of the knowledge required to develop innovations, it is almost impossible, even for the largest organizations, to rely on internal expertise. The exchange becomes essential and allows consolidation of both the innovation ecosystem and each stakeholder (companies, organizations, etc.).

2.2. Definition

In order to respect the social and environmental imperatives, SI appears as a type of innovation that can contribute to responding simultaneously to the three dimensions of SD. This type of innovation is all-encompassing, as it offers a range of transdisciplinary and inter-sectoral tools and modes of operation depending on the actors and sectors of activity involved. Whether it is radical or incremental, SI has a systemic and structuring character; it should provoke transformations that contribute to the evolution of our societal systems towards more sustainable trajectories. SI can thus be seen as a leverage tool for the processes and experiments of the socio-ecological transition of anthropic systems, at all societal scales and in an inter-sectoral manner (economy, technology, social, governance, justice, education).

We, therefore, propose the following definition of sustainable innovation (SI):

> *A new service, product, process, or practice, arising from collaboration among different actors, that contributes to operate a socio-ecological, interdisciplinary, structural, and systemic transformation aimed at making society compatible with planetary limits and ensuring human well-being and societal resilience* [13].

Many actors can contribute, interact, and collaborate to stimulate SI. These include educational and research institutions, political leaders, businesses, scientists, social organizations, national and international organizations and citizens. SI is indeed nourished by the interactions between different actors, but it also generates new networks. However, it seems crucial to examine the transformative role that SI can play at the scale of societal systems. To this end, the field of Sustainability Transitions seems relevant to better understand the complex dynamics that can guide profound systemic changes.

3. Understanding the Dynamics of Innovation That Underlies Transformation towards Sustainability: The Field of Sustainability Transitions

To initiate and accelerate a process of transition, it is necessary to recognize the complex and evolving nature of societal systems [14]. It is also required to overcome the issues of "path dependency" and "lock-in" that hinder the structuration of SI, while ensuring the dominance of incumbent systems [15,16]. Applied to societal systems, transitions result from a multiplicity of gradual changes structured on different scales and whose components co-evolve and reinforce each other [17–19]. To apprehend these complex phenomena of deep change, the scientific field of Sustainability Transitions is helpful to understand how innovations can sprout and contribute to the reconfiguration of incumbent systems [20,21]. Two major problems drive this field: the analysis of the dynamics of systems changes and the governance processes that can steer these changes. The sociotechnical and the governance approaches are two subfields providing conceptual and prescriptive tools to address these issues.

3.1. Transition of Sociotechnical Systems (STS)

The sociotechnical approach is concerned with systems that fulfill major functions in society (mobility, agriculture, energy) [22]. STSs are characterized by a complex articulation of social and technical elements: artifacts; infrastructures; user practices; institutions; business models; markets; policies; resources [23]. The interweaving and co-evolution of these components make the trajectory of STSs steady in time and space. They are thus a little subject to the phenomena of radical reconfiguration [24]. However, transitions may occur, fueled by systemic innovations [25]. In this respect, the analytical framework of the Multi-Level Perspective (MLP) allows us to understand the structure and evolution of a transition, as well as how innovations can emerge and transform existing systems [23,26].

The Multi-Level Perspective (MLP)

The MLP provides an evolutionary and structural interpretation of transitions through a "nested hierarchy" divided into three sociotechnical levels: the landscape (macro), the regime (meso), the niches (micro) [27]. It is within the regime that the core of the transition

is carried out [17]. As the deep and stabilizing structure of STSs, the regime consists of an alignment of cognitive, regulatory, and normative rules [27]. This alignment corresponds to the dominant way in which STSs performs a societal function. Incremental innovations may arise within the regime itself, but these will contribute to its optimization rather than its transformation. The landscape is the exogenous environment of the STSs and those whose modulations influence the lower levels of the regime and the niche. The landscape includes trends (international agreements, resource scarcity) and shocks (wars, pandemics). The landscape puts pressure on the regime, which most of the time readjusts to adapt itself to it. Niches are virtual or physical spaces outside the regime that offer protection and autonomy for the development of radical innovations. Niches offer latitude for frontrunners to experiment, exchange knowledge and consolidate radical innovations [28].

According to the MLP, a transition requires interactions within processes from the three levels of the STS [29]. At the macro level, the accumulation of pressures from the landscape must destabilize the regime to the point that it cannot readjust. This provides opportunity for radical innovation to overcome the weaknesses of the regime. If the innovation is sufficiently mature and structured, it can transform the configuration of the subsystems of the regime. The new stable realignment within the regime will mark the transition, which will have a long-term impact on the landscape. According to Sustainability Transitions, the accumulation of reconfigurations of different STSs towards sustainable pathways is the key to a global socio-ecological transition [30].

3.2. Governing Transitions through Sustainable Innovations: Transition Management (TM)

To promote the socio-ecological transition, it seems essential to generate and consolidate SI that is likely to bring about profound structural changes in societal systems. In this perspective, the governance of transitions is a stream of Sustainability Transitions that explores analytical and prescriptive tools to stimulate and foster transition processes [31]. The research of this school stems from the idea that transitions cannot be controlled by top-down policies, but rather involve a diversity of actors, experiments, and processes of social learning [18,21]. The most sophisticated tool of this stream is Transition Management (TM), a collaborative and reflexive governance approach aimed at encouraging and channeling societal change [18,32].

The TM is deployed in a four-step cycle mobilizing research, co-creation, innovation support and networking of actors [18]. In the strategical phase, an organizational structure establishes a "transition arena": a network of actors gathered periodically to co-produce a collective intelligence and define major long-term objectives for a societal system. The tactical stage consists of developing prospective scenarios to explore the possible futures of the system, then putting them up for debate through participatory activities. This input will help to articulate a vision of a desirable pathway to achieve the objectives defined in the first step. A backcasting activity is used to plan the measures to be undertaken to reach the envisioned future. This strategic planning will be synthesized into a transition agenda. Intended to the frontrunners, the agenda is a repertoire including experiments to be implemented, coalitions to be established and potential sociotechnical arrangements [33]. In the operational phase, the arena selects transition experiments to be implemented. These experiments have two objectives. First, they explore the transformative potential of SI. More broadly, the experiments are intended to act as showcases of change to foster social learning and collective action in favor of transition [34]. The reflexive phase consists of assessing the entire cycle, but also measuring the impact and scaling-up potential of the experiments. This evaluation will enrich the transition agenda and the knowledge of the system for future TM cycles.

4. The Application Fields of Sustainable Innovation

Through the great diversity of its operationalization modes, SI promotes an interdisciplinary dialogue likely to generate or support structuring solutions. It is therefore an all-encompassing concept that can be mobilized by various fields of research and actions

related to sustainability. There are thus several complementary ways of applying SI. Thus, the circular economy, regenerative design and transformative social innovation constitute three examples of applied research fields, of which SI is an integral part.

4.1. Circular Economy

The circular economy (CE) is a systemic approach aiming at a more sustainable mobilization of resources through a looping of material and energy flows within the production and consumption patterns [35]. CE includes strategies that fall into two broad categories: 1. rethinking production–consumption patterns to limit resource extraction and protect ecosystems; 2. optimizing the use of resources that are already mobilized in value chains to limit waste and pollution generation [36]. The strength of CE lies in the possibility of applying it at various scales of operation that are complimentary. For example, organizations can rethink their supply chains, business models or industrial operations. Due to the complexity of value chains, the implementation of organizational strategies also requires a multi-stakeholder collaboration that implies moving from a logic of competition to one of coordination and partnership. CE can also be implemented according to a territorial logic [37]. This implies developing a systemic approach that integrates actors, material flows and infrastructures in a defined geographical area [38,39].

The concepts of CE and SI are directly connected, can feed each other and therefore become reciprocally enriched. Indeed, the circularization of resource flows within an economic model that is mainly linear requires a systemic rethinking of production and consumption patterns and represents an SI in itself [40,41]. Furthermore, the implementation of CE strategies involves many unknown variables, as new ways of understanding resources and their use must be introduced [42]. It is, thus, necessary to mobilize SI throughout the value chains of products and services to create new circular loops.

4.2. Regenerative Design

Regenerative design (RD) can be defined as a set of technologies, practices and strategies that enable the regeneration of socio-ecological systems [43,44]. RD is part of a broader environmental scope than sustainable development, as it aims at rebuilding natural capital and enriching natural conditions. The aim is to develop a relationship of mutualism between anthropic and natural systems. RD is a holistic and transdisciplinary process that adopts a systemic and evolutionary perspective of its objects of analysis (product, service, building, neighborhood, city). This design approach includes human and non-human stakeholders (communities, watersheds, ecosystems) and considers the key processes of the worked system. RD is rooted in the fields of construction and architecture, but the approach can be applied to several sectors of activity and at various scales. One of the most successful applications of the regenerative approach is embodied by permaculture, which allows intensive farming while capturing carbon dioxide and enriching the soil and local biodiversity.

4.3. Transformative Social Innovation

Transformative social innovation (TSI) aims to radically reconfigure social systems towards increased sustainability by proposing new discourses and solutions that break with dominant societal models [45]. TSI thus implies profound changes in the structure of incumbent institutions and relies on the institutionalization of change on a more global scale [46,47]. Its application is mostly the result of bottom-up organizational movements, some examples of which are the Transition Network, the Global Ecovillage Network, and the Slow Food. These different initiatives all propose new discourses and visions accompanied by a set of solutions supported by new structures. The four movements have also initiated changes in the dynamics and relationships between actors in their respective fields of innovation. More specifically, it involves new combinations of ways of doing, organizing, learning, and designing, offering alternatives to the services offered by dominant institutions [47].

The three previous examples illustrate the transdisciplinarity of SI, which allows it to bridge different fields of application while generating a potentially transformative synergy. By its theoretical value and its operational character, SI has the strong potential to play a key role in the transition of our societal systems towards greater harmony with the ecosphere and the more equitable distribution of resources.

5. Conclusions

Faced with many challenges imposed by sustainable development, it remains very difficult to adequately, rapidly and radically transform our socioeconomic models. Sustainable innovation thus appears to be a cross-cutting concept with the potential to act as a powerful lever to accelerate a shift towards fairer and more eco-responsible modes of production and consumption, as well more resilient societies. This still-emerging concept can represent an unquestionable driver of change to achieve a socio-ecological transition that will make it possible to reach the 17 UN SDGs.

SI practice should however be supported by theoretical research on Transition Studies and Transition Management. It is then crucial to mobilize the different actors in research, industry, politics and community organizations in order to create a favorable environment and the appropriate interaction platforms for the deployment of SI on a large scale. Stakeholders and actors of the ecosystem are encouraged to foster the development and the deployment of the major themes and approaches likely to support SI towards a resilient, inclusive and sustainable society.

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Proceeding Paper

Ecological Efficiency and Sustainable Regional Development in Russia †

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Abstract: We proposed an approach to evaluate ecological efficiency of an economy as the ratio of the created output of non-primary goods and services to the input of consumed resources (labor, capital, raw materials, environmental costs) using the DEA. The eco-efficiency of an average Russian region has been growing since 2003. Using econometric calculations, we have established it grew faster in densely populated areas with a high share of high-tech services, investment attractiveness, and intensive technology implementation; it decreased in most northern and Siberian regions. The simultaneous growth of GRP per capita and ecological efficiency in a region was considered as a model of sustainable development. We observed this pattern more than half of the period 1998–2017 in most Russian regions although the Russian economy mainly developed due to the extraction of raw materials.

Keywords: regional development; sustainability; Russian regions; environmental problems; data envelopment analysis; Kuznets curve; quality of economic growth

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1. Introduction

Climate change, ecological, and social problems require new goals, metrics and tools of economic policy, based on the principles of sustainable development [1,2]. However, over the latest 20 years, the increase in energy prices has led to a raw material growth model prevailling in Russia [3]. Could this growth have led to more sustainable regional development?

In our work, in accordance with the paradigm of sustainable development, ecological efficiency is the ability of economic agents to increase non-resource output in a region while minimizing the resources used (labour, capital, raw materials) and the level of environmental pollution. In fact, this can be used as an additional indicator for monitoring the quality of economic growth at different territorial levels: countries, regions, cities, etc. The simultaneous growth of per capita GRP and ecological efficiency might be considered as a possible approach to sustainable regional development.

The purpose of our work is to assess the ecological efficiency of the Russian regions and to determine the factors of its dynamics from 1998–2017.

2. Materials and Methods

To measure the sustainable development dynamics, the economic, social, and environmental characteristics are often used [1,2,4]. Hence there are problems in justifying the choice of indicators and the ratio of weights between them within the integral indices. In our article, we use an approach based on data envelopment analysis (DEA), which considers a combination of many variables. The method is based on linear programming [5].

Regions are compared with each other by the results of their activities, taking into account the resources they use (cost-benefit analysis) [6]. In the production function, costs are the estimates of the factors of labour, capital, and natural resources (fuel, water, land resources, etc.), and output is the gross regional product (GRP). Undesirable results, such as pollution [7], in our opinion, should be considered as environmental costs. In this case, we can consider that an ecologically efficient region with estimation 1 is a region that, in comparison with others, provides output with a minimum number of resources used and minimum pollution. Efficient regions are on the border of production capabilities. The least efficient regions have a DEA value close to zero.

Empirical studies confirm the higher ecological performance of developed countries and regions [7,8]. This confirms the hypothesis of a ʌ-shaped relationship between economic growth and environmental pollution [Grossman, Krueger, 1991], called the ecological Kuznets curve. In the transition from an agrarian to an industrial society, costs rise. Then, the growing share of the service sector and the introduction of new technologies can reduce the number of resources used and reduce pollution. At the same time, as incomes grow, the demand for a clean environment increases.

To assess the results of sustainable economic activity in the region, we propose an indirect indicator of the output of non-primary goods and services-gross regional product (GRP) in constant prices minus mining activities and federal transfers, billion rubles. Federal transfers accounted for in GDP are mainly associated with the redistribution of oil rent between regions, therefore they are excluded from the assessment of regional ecological efficiency.

We use several variables that characterize resource costs:

- labour: number of labour force (million people);
- capital: the cost of fixed assets in constant prices (billion rubles);
- natural resources: electricity consumption (million kWh); water consumption (million cubic meters); value added by type of activity "Extraction of minerals" in constant prices (billion rubles);
- environmental costs: emissions of pollutants into the atmosphere (thousand tons).

The official data of the Russian statistical service from 1998–2017 were used.

Since the comparison in DEA is made for a sample, its change may lead to a revision of the estimates. The calculations were carried out simultaneously for the entire period 1998–2017, which made it possible to trace the dynamics of ecological efficiency.

3. Results and Discussion

3.1. The Main Trends

In Russia, energy intensity increase during the crisis period of the 1990s, when output fell faster than energy consumption, but declined in the 2000s as the economy grew, underutilized production capacities were loaded, assets were renewed, and the price of energy resources rose. The share of fossil fuels in energy consumption generally declined prior to the 2009 crisis following higher raw material prices, but the share of renewables has declined since the mid-1990s due to a decline in the number of small hydropower plants. Due to the fall in industrial production, carbon dioxide emissions decreased in the 1990s, but then there was an increase due to growing capacity utilization and motorization.

Non-resource output more than doubled over the period due to the growth of the service sector, especially in large agglomerations of the country: trade, finance, transport, information, and communication technologies, etc. Minerals, considered the main source of growth, due to the favourable market conditions increased by 1.8 times. Economic growth in the early 2000s was accompanied by an increase in air pollution, but from 2005 to 2015, the volume of emissions shortened due to a reduction in the number of large industries, modernization of thermal power plants and their conversion to natural gas, the development of resource-saving technologies in new industries. This phenomenon is consistent with the Kuznets ecological curve hypothesis. But in 2018, the processes of motorization led to some excess of the values of 2000. Water use was reduced throughout

the entire period due to the modernization of water infrastructure, reduction of losses, and the closure of a number of large water consumers, including pulp and paper mills. Electricity consumption grew following economic growth, but at a slower pace, which is associated with a decrease in the specific share of energy-intensive industries, in particular, the closure and re-equipment of outdated metallurgical plants, and a decrease in losses after the modernization of power grids.

Eco-efficiency has decreased in most regions with low-tech industries: in Kemerovo (coal mining, metallurgy); Rostov (coal mining); Orenburg (oil, gas, copper) regions; Perm Territory (oil, gas, mineral fertilizers production); Karelia (metal mining, pulp, and paper industry); as well as areas that have increased their production capacity: Amur (iron); Astrakhan (natural gas); Irkutsk (gas, coal).

3.2. The DEA Estimations

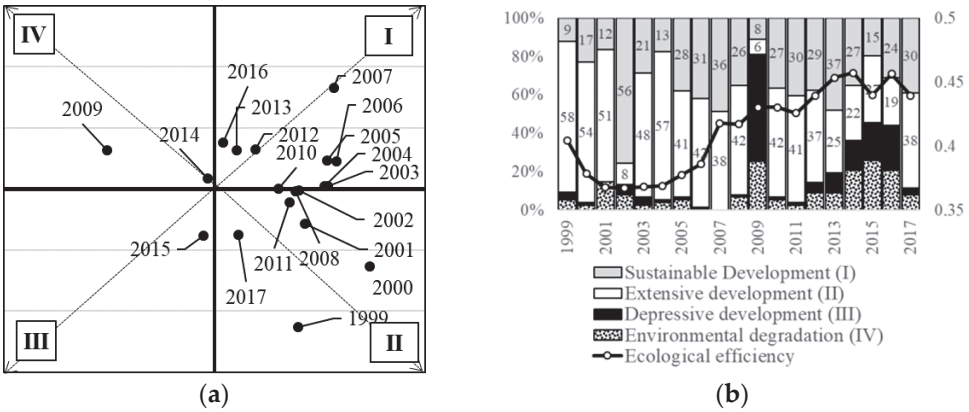
We identified several regions on the border of production capabilities, which demonstrate the best practice: Moscow, St. Petersburg, Yaroslavl, Sverdlovsk, Bryansk, Tambov regions, Mordovia, and Chuvashia. Increasing the efficiency of an average Russian region and becoming close to the leaders while maintaining the values of GRP, fixed assets, and labour force, would require a reduction in water, electricity, and emissions by 56%, and the volume of mineral extraction by 96%.

However, the volumes of non-resource output, and, accordingly, the estimates of the leaders' efficiency may be overestimated. First, despite the mechanical exclusion of mining from our estimates of non-resource output, the mining sector remains closely linked to the economies of all regions through financial services, trade, budget spending, etc.; the sector has a stronger influence on the largest agglomerations (Moscow, St. Petersburg). Secondly, although the federal budget transfers to the regions were excluded from the estimates, the natural resource rent was distributed by financing state organizations, whose products and services constitute a significant part of the non-resource output of the less developed leading regions (for example, Mordovia and Chuvashia). In general, the formed centralized fiscal system in Russia helped to equalize socio-economic and environmental inequality.

A preliminary analysis shows that regions with large agglomerations and relatively diversified economies are more ecologically efficient: Moscow, St. Petersburg, Nizhny Novgorod, Omsk, Sverdlovsk, Leningrad, Chelyabinsk regions. Due to the high share of the service sector, and the introduction of new technologies in these regions, the indicators of energy consumption, water use, and air pollution are lower. Separate regions with a high share of agriculture and public sector are also efficient: Chuvashia, Mordovia, Kabardino-Balkaria, Bryansk, Tambov regions. Due to the small number of large industries and lower incomes of residents in these regions, energy consumption and emissions from factories and vehicles are lower.

Low ecological efficiency was observed in regions with a high share of low-tech industry and, accordingly, with high specific volumes of emissions and energy consumption: Kemerovo region (ferrous metallurgy, coal mining), Krasnoyarsk region (non-ferrous metallurgy, pulp, and paper industry, brown coal mining), Orenburg region (ferrous and non-ferrous metallurgy, gas production), the Komi Republic (oil, gas and coal production), Irkutsk region (non-ferrous metallurgy, pulp, and paper industry), Khanty Mansi Autonomous Okrug and Tomsk region (oil and gas production).

The ecological efficiency of the average region in Russia declined from 1998 to 2003 (Figure 1b), when the fall in the ruble exchange rate and favourable external conditions contributed to the high utilization of obsolete fixed assets, the policy of preserving a number of inefficient and resource-intensive industries prevailed. However, with the renewal of production capacities and the structural transformation of the Russian economy, efficiency began to grow again in 2011 and increased until 2014. Economic growth then slowed down on the back of rising emissions from automobile transport and rising electricity consumption.



(**a**) (**b**)

Figure 1. (**a**) Growth of GDP per capita in Russia (horizontal axis) and increase in ecological efficiency of an average Russian region (vertical axis) in 1998–2017, %. Method was firstly introduced by V. Bityukova [9]. (**b**) The structure of development models by the number of regions (%) and ecological efficiency (right axis) of an average region in 1999–2017.

The fastest growing eco-efficiency was in regions with the following features:

(1) leading in terms of investment attractiveness, which have launched new production facilities and services, including through foreign direct investment and technology imports [3]: (for example, Leningrad, Belgorod, Yaroslavl, Kaliningrad regions);
(2) large metallurgical centres, where large-scale modernization took place (for example, Sverdlovsk, Chelyabinsk, Vologda, Lipetsk regions);
(3) producing regions where emissions of associated natural gas have decreased (for example, Sakhalin, Tomsk regions, the Komi Republic);
(4) regions that have lost their former production specialization as a result of market transformations (for example, Ivanovo, Saratov regions, Kurgan, Volgograd, Omsk regions);
(5) regions where land prices were actively increasing in large agglomerations, and the processes of tertiarization intensified—the growth of the service sector (for example, Moscow, Omsk, Sverdlovsk, Chelyabinsk regions).

3.3. Regional Sustainable Development

Comparing the dynamics of the eco-efficiency of an average Russian region and the dynamics of GRP per capita, four development models can be distinguished (in brackets are the quadrants in Figure 1a):

- sustainable (I)—economic growth and ecological efficiency increase (for Russia it was observed in nine out of twelve years);
- extensive (II)—economic growth, but a decrease in ecological efficiency (seven years);
- depressive (III)—a fall in per capita GDP (GRP), combined with an increase in ecological efficiency in the crisis years of 2009 and 2014;
- environmental degradation (IV)—economic contraction with a decrease in ecological efficiency in the crisis year of 2015.

Figure 1b clearly shows how regions differ in terms of development models in certain years and how strongly this is influenced by the crisis phenomena. In a third of the period considered, the model of extensive development was implemented, in a quarter-the model of sustainable development. Economic crises (2008 and 2015) led to a decrease in ecological efficiency in most regions, which is associated with a higher rate of decline in output compared to a reduction in costs. Therefore, the share of regions that implemented the model of depressive development and ecological degradation grew; the number of the latter is especially high in 2009 and 2015.

In 43 out of 74 regions, the sustainable development model has been implemented more often than other models, or as many years as the extensive model, and more than eleven years in St. Petersburg, Tambov, Leningrad, Tula, Lipetsk, Vologda, Oryol regions, Krasnoyarsk Territory, Dagestan, Transbaikal Territory, and Khakassia. In 34 regions, predominantly of raw materials specialization, an extensive development model prevailed. For more than five years, depressive development was observed only in Komi and Magadan Oblast, where the number of residents decreased due to migration to the southern regions, GDP shrunk, but, accordingly, the load on ecosystems also fell.

3.4. Factors of Ecological Efficiency

To identify and assess the influence of various factors described above on the dynamics of the ecological efficiency of regions, we have built several multifactorial models (Table 1). All dependent variables are weakly correlated with each other, there is no reason to assume the presence of multicollinearity. For verification purposes, several calculation methods are presented. The results of econometric assessments have confirmed the previously identified regional patterns.

Table 1. The results of econometric modeling. Dependent variable: assessment of the ecological efficiency of the Russian regions according to the DEA method (from 0 to 1). 1184 observations. Random effects.

Number	1	2	3
GRP per capita, thousand rubles per person	−0.001 (0.0003) ***	−0.0007 (0.0004) *	−0.0006 −0.0004
GRP per capita, thousand rubles per person ^{2}	1.5×10^{-6} (5.2×10^{-7}) ***	1.1×10^{-6} (5.5×10^{-7}) *	9.4×10^{-7} (5.5×10^{-7}) *
Share of the non-manufacturing sector in GRP,%	0.004 (0.001) ***	0.006 (0.001) ***	0.005 (0.001) ***
Ratio of imports of machinery and equipment to GRP,%	0.001 (0.0004) ***	0.001 (0.0004) **	0.001 (0.0004) **
Ratio of crop production to GRP,%	0.005 (0.002) ***	0.006 (0.002) ***	0.006 (0.002) ***
Crimes per capita	-2.4×10^{-5} (1.1 × 10−5) **	-3.5×10^{-5} (1.2×10^{-5}) **	-3.5×10^{-5} (1.2×10^{-5}) ***
Average number of study years of an employee	0.02 (0.008) **	0.02 (0.007) ***	0.02 (0.007) ***
Population density, people per sq. km	4.1×10^{-5} (1.1×10^{-5}) ***	3.2×10^{-5} (1.1×10^{-5}) ***	2.8×10^{-5} (1.1×10^{-5}) ***
Number of cars per capita		–0.0003 (0.0002) **	–0.0004 (0.0002) **
Coal is mined in the region (dummy variable)	–0.16 (0.05) ***	–0.16 (0.05) ***	–0.1 (0.05) **
Ferrous or non-ferrous metals are mined in the region (dummy variable)			–0.18 (0.06) ***
Constant	0.44 (0.1) ***	0.32 (0.1) ***	0.37 (0.1) ***

Estimates of the coefficients and directions (+/−) of the influence of variables. The robust standard errors are in parentheses. Asterisks indicate significant estimates: ***-most significant (p-value < 0.01), **-less significant (p-value < 0.05), *-least significant (p-value < 0.1).

It was confirmed that post-industrial regions with high per capita GRP and agricultural regions with low productivity and pollutant emissions were more efficient, even consider-

ing many other factors. The positive, albeit weak, coefficient of the squared variable GRP per capita confirms the hypothesis of the ecological Kuznets U-curve.

Equipment upgrades have reduced emissions and improved energy efficiency in factories. Therefore, the higher is the share of imports of machinery and equipment in GRP in a region, the higher the ecological efficiency could be. The coefficient at the variable "the ratio of the investments to GRP" is not significant, that is, in regions with large volumes of investments there were no higher values of eco-efficiency. Since these are predominantly northern regions, in which most of the investments were directed to the raw materials sectors.

The region's ability to attract investment in new industries and renew funds depends on the risks for investors and entrepreneurs, as well as on the concentration of human capital, so regions with high crime and low education levels are generally less efficient. For policy purposes, it is important that these factors can be influenced by regional authorities.

The indicator of the share of crop production in GRP is positively associated with ecological efficiency, respectively, in the northern regions, where this share is minimal, ecological efficiency is lower, and in many cases, it decreased due to growing transport, energy, and other costs. It was confirmed that the regions where coal and metals are mined are, on average, less ecologically efficient. Thus, the possibilities for sustainable development are, to some extent, determined by natural conditions and resources.

In regions with a high population density, ecological efficiency is higher and increased due to agglomeration effects: the variety of activities, the intensity of agent connections, the size of the market, etc. due to growing pollution. For the purposes of regional policy, it is important that it is impossible to overcome the environmental problems of large cities by building highways and increasing the number of cars, but only by restricting the use of personal vehicles.

Environmental policy measures (investments in environmental protection) turned out to be insignificant in any of the models (contradicting our initial hypothesis), since they are aimed at solving the existing problems of ecologically less efficient regions.

4. Conclusions

Economic growth in Russia over the past twenty years has been based primarily on the use of the natural resources of certain regions. However, the mechanisms of regional policy based on interbudgetary (federal) transfers made it possible, to a certain extent, to smooth out socio-economic and ecological inequality.

Many regions that did not have significant natural resources also developed at a high rate [3]. This created the conditions for the implementation of a sustainable development model that combines the growth of per capita GRP and the growth of ecological efficiency. This model was observed in Russia in 2003–2007, 2010, 2012–2013, and 2016, which can be explained by the increase in the share of the non-manufacturing sector and the renewal of fixed assets. Therefore, the model prevailed in regions that actively attracted investments in new production and services: in Moscow, Leningrad, Kaliningrad, Belgorod regions, in production centres that carried out large-scale modernization: in the Vologda, Lipetsk, Sverdlovsk regions.

The likelihood of implementing a sustainable development model in a region depends not only on objective factors (geographic location, population density, economic structure, etc.), but also on the decisions of federal and regional authorities (interbudgetary transfers, investment incentive policies, improving the investment climate, etc.). Therefore, the proposed tool for assessing the quality of economic growth may be in demand when making political decisions.

In recent years, the share of regions that are implementing a sustainable development model has been decreasing against the backdrop of unstable economic growth, an increase in the share of the raw materials sector in the economy, and pollution from vehicles. But in 2020, due to the economic crisis caused by the consequences of the pandemic and the fall in oil prices, there is a high likelihood of a depressive development model that combines a

drop in per capita GDP (GRP) with an increase in ecological efficiency. This has already been observed in the crisis years of 2009 and 2014. The pace of motorization and, in general, the anthropogenic load as a result of quarantine measures and a reduction in the population's income will decrease, while small and medium-sized businesses will suffer, and growth based on the extraction of raw materials may stop.

Our research complements the list of works devoted to the goals, factors, and instruments of sustainable regional development in Russia. The approach proposed by the authors to assess ecological performance can be used in studies of economic development and in setting political goals. The results and conclusions obtained can be used to develop recommendations regarding the localization of sustainable development goals in different types of regions.

The national project "Ecology" in Russia by 2024 envisages a significant reduction in emissions of pollutants from stationary sources, the improvement of water bodies, and the expansion of environmental activities. Our calculations allow us to justify a number of additional tools.

Most regions of Russia require the creation of incentives for a significant increase in the efficiency of extraction and processing of raw materials, energy and water conservation, and reduction of atmospheric pollution. In many regions, there is a high potential for improving the energy efficiency of buildings and the development of alternative energy sources: wind, solar, tidal, geothermal, etc. [10].

We consider it expedient to introduce specialized financial instruments: a tax deduction for small companies and homeowners to compensate for part of the costs of installing roof panels, and wind turbines [10], the introduction of environmental vouchers; you need to expand your connectivity to public networks. Various measures on emission quotas and taxation have not lost their relevance.

In order to reduce emissions from vehicles in the largest agglomerations, it will be necessary to introduce the principles of an eco-city into the practice of urban planning activities: the development of public electric transport, bike paths, car sharing, a decrease in the number of stories of buildings, restrictions on the movement of personal vehicles and other measures.

Most of the measures supporting the development of high-tech industries and knowledge-intensive services actually increase the possibilities for sustainable development. In turn, increasing the complexity of regional economies through the introduction of eco-innovation, and resource-saving technologies contributes to an increase in the productivity and competitiveness of regions. The structural transformation of the Russian economy is interconnected with an increase in ecological efficiency, and, accordingly, with opportunities for sustainable development.

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Proceeding Paper

Technical and Vocational Education and Training: Examining Changing Conditions in India †

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Abstract: Sustainable Development Goal 4 emphasizes creating lifelong learning opportunities and imparting needed practical skills through quality technical and vocational education. TVET holds great potential for economic mobility and development in India, which has a large working-age, unemployed population. Although rapid strides have been made in creating a network of formal institutions providing a wide range of skills, TVET, in India, is currently limited, and plagued with several issues, worsened by the current COVID-19 pandemic. The paper undertakes a comprehensive review of these issues, offering a comparative analysis with successful TVET systems of Germany and China, and exploring opportunities for repairing TVET in India.

Keywords: technical and vocational education (TVET); SDG 4; India; Germany; China; comparative analysis; COVID-19; challenges; evaluation

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1. Introduction

Education, as a holistic concept, according to Sustainable Development Goal (SDG) 4: "Quality Education", extends to "lifelong learning" that promises lucrative job opportunities aligned with respective interests, and skills facilitating professional and personal growth. TVET has been perceived as an essential tool for socio-economic development by the enhancement of productivity, and subsequent returns from the vast human capital resource available in a country such as India. As emphasized by the UNESCO–UNEVOC report [1], TVET offers diverse avenues for career advancement, skilled manpower that drives the economy of nations, and a sense of self-reliance. This helps lower school drop-out rates and empower the unskilled workforce that possesses untapped productive potential; this is particularly important for a country such as India, with an unemployment rate of 5.3% and youth unemployment rate of 22.3% in 2019 [2]. These have since worsened due to COVID-19, further emphasizing the need for changes in TVET. However, several issues have been persistent over time, and India has faced challenges in terms of bridging the demand–supply gap, assuring the quality training of both teachers and students, the effective integration of industrial skills in the formal education, curriculum flexibility, active stakeholder engagement, and the upgradation of relevant technology.

The COVID-19 global pandemic has largely disrupted our lifestyle and impacted the education sector and labour market, to the extent of substantially offsetting the progress achieved under SDG4 [3]. The rampant loss of jobs and shift to online teaching modes in these unprecedented times has made matters worse for countries in terms of social, economic, and environmental domains. The World Bank presses on the need to modify TVET in order to effectively mitigate the impact in these sectors, and make institutions more resilient in their approach to impart the required knowledge and skillsets to empower

the working age group. The focus on practical skills and engaging students to adapt to new technologies and respond to the state of emergency could greatly contribute to nations building back better [4].

This paper aims to put forth key challenges in India's TVET system, with respect to target 4.3 "by 2030 ensure equal access for all women and men to affordable quality technical, vocational and tertiary education, including university" [5], and the changing conditions due to the COVID-19 pandemic. A comparative analysis with Germany and China provides insight on existing gaps and recommendations to mitigate the same. Following this, suggestions for effective evaluation of the TVET system are provided to integrate factors that facilitate quality education in this regard. Lastly, we conclude with highlighting key takeaways and indicating a way forward.

2. Literature Review

2.1. Structure of TVET in India

Technical and vocational education and training (TVET), broadly defined by UNESCO [6] as "Those aspects of the educational process involving, in addition to general education, the study of technologies and related sciences, and the acquisition of practical skills, attitudes, understanding and knowledge relating to occupations in various sectors of economic and social life". TVET is a crucial part of imparting practical skills, ensuring employability through upskilling, economic mobility, the full utilization of national resources, and achieving inclusive and sustainable development for all. TVET can take place at different levels of education or in the form of work based training, and can be acquired from formal sources, such as educational institutions, and non-formal sources, such as flexible, community level, and short term programs, as well as through informal means. This paper examines the formal structure of vocational education in India, as well as the challenges faced by it.

Vocational education in India is organized under different programs, with secondary education and diploma courses promoted by the Ministry of Human Resource and Development, and National Trade Certificate courses organized under the Ministry of Skill Development and Entrepreneurship. At this level, TVET is mainly imparted by public or privately owned industrial training institutes (ITIs). Under the two overarching ministries, TVET is organized under a number of autonomous or semi -autonomous bodies and public–private partnerships that are responsible for developing TVET policy, governance of institutions, financing TVET, and setting up incentives, teacher training, and developing framework for qualifications, norms, and quality standards. Aside from this, TVET policies also exist on a state level and through non-formal education, under various urban and rural development and employment generation schemes initiated by the government. The Ministry of Skill Development and Entrepreneurship is primarily responsible for financing TVET in India. Specialized teacher training programs for TVET have also been created, although these are limited in number, and prior specialized training in education is not a formal requirement. Qualifications for TVET are monitored under the National Qualification Framework, and quality is looked after by various bodies, such as the All India Council for Technical Education (AICTE), the National Development Agency (NSDA), and the Directorate General of Training (DGET) [7]. At the time of writing, India has a total of 14,605 ITIs under the National Council for Vocational Training, DGET, and the Ministry of Skill Development and Entrepreneurship [8]. The National Education Policy 2020 (NEP) has the potential to introduce substantial changes in TVET provision. One major change is necessitating the integration of TVET into the programs of existing secondary and higher education institutions, thus providing a dramatic rise in provision of TVET and bringing TVET into closer contact with other areas of education. It also proposes a number of other changes to encourage TVET, such as streamlining pathways from TVET to other forms of higher education, placing emphasis on teacher training, promoting social and emotional learning and the adoption of innovative methods, and addressing low enrollment [6].

2.2. Challenges of TVET in India

Despite such a decentralized system, multiple concerns have surfaced regarding the implementation of TVET. As shown in India's country profile, the Pandit Sunderlal Sharma Central Institute of Vocational Education (PSSCIVE) has listed several challenges [9]. The supply–demand gap is evident, considering the massive figure of approximately 12.8 million people entering the market annually and that the capacity of vocational training courses is limited to roughly 2.5 million people. According to the periodic labour force survey, only 2.74% of India's working age population to have formal training in TVET [6]. The lack of diversity and flexibility in courses, along with the absence of guidelines to expand opportunities beyond formal authorized institutes, poses another hurdle. The fact that modifications made in the TVET system and curricula are not able to maintain the same pace as the rapidly evolving market demands renders some skills unproductive. Improper training, along with a lack of specific mandatory qualifications of TVET teachers and trainers, hampers the effective delivery of instructions and information. The poor incentive structure does not help attract more people in this profession to address the existing shortage of teachers. Additionally, engagement of employers and stakeholders, at all levels, and the introduction of recent technologies to enable improvement in skill development and associated activities, continues to lag. Apart from this, the stigma associated with enrolment courses that perceives TVET as inferior, and an alternative for students unable to cope with academics, must be overcome [10]. This may be attributed to the ineffective integration of industrial knowledge in the school curricula, which incorrectly presents this as a trade-off, when the learnings from both are complementary with one another. Arguing along the same lines as PSSCIVE, Kumar (2015) highlighted that following the multiple agencies and certifications, overlapping courses, and institutional responsibilities creates more confusion for students. He also emphasized on the need for better experiential learning and methods of gaining students' interest, and reiterated the academic–industry linkage for increasing employment opportunities. TVET provision is also hampered by a number of existing socioeconomic inequalities, including those of gender, disability, caste, class, and rural/urban residence.

While the NEP's ambitious plan is aimed at ameliorating some of these issues, TVET systems in India will require a number of reforms to truly achieve the goals outlined under SDG 4. The COVID-19 pandemic has further created a number of new challenges as well as exacerbating existing inequalities.

2.3. COVID-19 Challenges in INDIA

The COVID-19 pandemic necessitated complete lockdowns and the shutdown of public spaces in order to arrest the spread of the virus. TVET is more vulnerable to these changes, compared to other forms of education, for several reasons. TVET heavily emphasizes practical and work-based learning, which is difficult to transition to an online model, particularly in cases where advanced machinery is used or in-person job training is required. As many as two thirds of the organizations in India also reduced available internships, and TVET institutions themselves faced economic hardship. Education continuity and student interest were thus impacted [3]. Existing inequalities, such as a sharp digital divide, lack of resources, infrastructure, and digital literacy further challenged the imparting of education online [3]. In developing countries, such as India, most TVET learners belong to disadvantaged socioeconomic backgrounds, and are thus even more affected than those in general education [4]. Women were also substantially impacted due to increased responsibilities at home and the loss of jobs in major women-dominated sectors [4,6].

3. Comparative Analysis

In order to explore opportunities for India to improve its TVET system, a comparative analysis between Germany, China, and India was performed and is described in this section. While the "dual system" of Germany has proven to be one of the best TVET systems

globally [11], China's model had a significant influence on improving the employment and prosperity of a country with a population as large as India's. Germany's education focuses on classroom teaching in specialized trade schools, along with job–work experience from industries and qualified trainers. Statistics reveal that there are roughly 300 officially recognized training programs, and that roughly 68% of fresh graduates immediately become employed at the firms they were trained in. As many as 500,000 new job positions are offered every year across all business firm and government fields [12]. Hence, the youth unemployment rate is negligible (ibid). China has three stages of vocational education: junior secondary, senior secondary, and postsecondary. Roughly 56.569 million students had graduated or completed their term of study by 2016 [13]. As stated by the Ministry of Education (2016), 25.10% of secondary school graduates, barring the ones from technical schools, continued their higher education, which was 5.08% more than was reported in the previous year [13]. This has further increased the employment rate. We explored how the exemplar cases in these two countries could inspire TVET in India, and offer solutions based on existing evidence of practices that can be contextualized in this country. This was performed on the basis of eight interlinked parameters that could help escalate the country's performance, as discussed below.

3.1. Stakeholder Involvement

India's TVET demonstrates a lack of flexibility in designing updated curriculums and coordination between agencies, despite recognizing the need for cross-sectoral collaboration for optimal utilization of expertise, resources, and knowledge [14,15]. In comparison, interlinkages between the government, research centers, vocational institutions, and industries, as well as the integration of stakeholders from the national to company level, have been vital to the German TVET system, helping achieve a balance between academic objectives and industrial skills [16]. OECD further recommended a coordination committee to improve efficiency and consider the mutual interests of stakeholders. China's TVET system similarly invites companies to aid in planning and setting standards for candidates [17].

3.2. Teacher Training

Strengthening the knowledge of TVET teachers is crucial for equipping students with necessary resources to increase labour market efficiency [18]. India's TVET lacks such training, affecting the delivery of TVET [9,14]. China made two month-long practical training sessions mandatory for teachers, to ensure updated knowledge [17]. Germany, as stated in the Apprenticeship Toolbox (2019) [19], requires teachers to have a degree in a specific field of interest, as well as qualify a state examination. In addition, teachers must attend specialized vocational education training. Trainers must undergo 1–2 years of training, and trainers in companies must also meet the occupational aptitude required for their industry. Trainers are offered suitable assistance and training kits.

3.3. Active Student Engagement

Multiple studies have proved that the engagement of students holds high value in determining their education and occupational outcomes; this is particularly required in the nascent stages to boost effective learning and even high self-efficacy [20]. The Yunnan Province of China improved upon the TVET system by making the modules student-centric with a revision in the curriculum to include Information and Communication Technology (ICT), in order to encourage participation and interaction over passive listening [17,21]. Competency Based Training (CBT) was encouraged to impart core skills that would be beneficial to students in the long term and help in their personal and professional growth [17]. Specialized trade schools in Germany employ supervisors, under whom the students spend almost 60% of their time gaining hands-on experience, while theoretical courses are developed according to their choice of occupation [12]. Given India's challenges in this regard, and the low participation rates, students do not feel encouraged to attend

vocational schools, and even report inadequate learning, which may be a result of the associated disinterest in the program.

3.4. Industry–School Collaboration

The quality of the TVET system in India has always been questioned, due to poor employment percentage despite completion of training programs. Major criticism has been levelled at the fact that the training offered does not correspond to actual labour market needs. Healthy cooperation between enterprises and vocational institutions in China involves engaging experts in the development and evaluation of programs. The companies and MSMEs acknowledge the contribution that TVET trainees and faculty can offer for their Research and Development, and, thus, show great interest in the mutually beneficial venture. Germany's TVET system consists of a curriculum in which students spend 1–2 days in a vocational school and the rest of the week learning skill-based lessons from a firm [12].

3.5. Incentive Structure for Teachers

Quality of trainers is a key resource for successful TVET, and trainers must be encouraged and fairly compensated to deliver the best education. However, TVET instructors sometimes encounter many hurdles in receiving training due to lack of assistance and benefits, as well as job schedules. There is, therefore, a need for financial assistance to promote teacher training; China has incentivized instructors to obtain certifications for both academic and practical skill in the required areas [22]. Germany has not awarded direct financial assistance, but does provide subsidies to businesses that meet specific criteria or train vulnerable populations. India, similarly, requires incentive structures to ensure better trained and quality instructors [23].

3.6. Technology Use

ICT can help improve education quality by fostering critical thinking, problem solving, and creativity through project based learning [24]. Communication technologies, open online courses, game based learning, etc., are gradually making their way into the Indian TVET system, but have yet to be effectively implemented on a large scale [25]. In China, to fulfill the demands of the trained, "ICT-capable" labour force required by industries, TVET schools are progressively incorporating technology into their training. As a consequence of aligning with industry needs, graduates from vocational institutions find work, including self-employment, quickly after graduation [17]. The Federal Ministry of Education and Research (BMBF) in Germany encourages needs-based dual vocational training that is tailored to the demands of an increasingly digital and networked economy. The digital equipment at inter-company educational institutions (ÜBS) is particularly fitted to the techniques through the special program ÜBS-Digitization [26].

3.7. Updated Curricula

India suffers from outdated curricula and designs that are not aligned with current market conditions. In Germany, regulatory mechanisms keep TVET information systems relevant via interactions between institutions, agents, and processes that create new qualifications and regularly update curricula [27]. China believes in the strategy of internationalization to develop modern educational material by inviting faculty from other countries and exposing students to exchange programs [28]. Innovation and upgradation is ensured by the autonomy awarded to TVET institutes to develop specific syllabi that must meet occupational standards, provided by the Ministry of Human Resources and Social Security, and the education standards set by the Ministry of Education [17].

3.8. Decentralised System

Germany boasts a well-developed TVET system that follows "an intricate web of checks and balances at all levels" [16]. Partnership between public and private institutes

for strategizing and funding is also a strong point. While the federal government takes responsibility for on-the-job training and funding for the latest curriculum development, vocational training in schools is supervised by the state government [25]. These link up with competent bodies, including industry employers, teachers, and trade unions, to run different kinds of TVET institutes [25]. China has established advisory committees at sectoral level to facilitate productive collaboration between schools and industries [21]. Local human resource institutes and social security bureaus share the responsibility of managing training institutes [29]. This is not reflected in India, where, despite the multiplicity of bodies involved in a decentralized structure, effective execution of stated responsibilities is still a challenge [14].

4. Response to COVID-19

Various initiatives have been adopted to respond to challenges related to COVID-19. Germany has sought to secure apprentice compensation, schedule learning in compliance to safety laws, and assist firms that provide apprenticeship positions [30]. In the last 10 years, China's vocational schools have made considerable progress in building IT infrastructure; during the pandemic, institutions with a stronger basis for digital campus building successfully adopted the online mode of teaching, preventing any further lag to the TVET system in the country [31]. COVID-19 also meant innovation in the Indian system. In the immediate case, emphasis was placed on continuing education online through several means. Initiatives included low technology television-based education under Swayam Prabha, online platforms, such as e-Skill India, that provide largely free online courses, and private initiatives such as the Nettur Technical Training Foundation, which promotes the use of virtual labs [6,32]. However, there is a dire need to increase digital infrastructure, train teachers, and reformulate TVET courses in the long term. Studies based on surveys of students emphasize teacher proficiency, appropriately structured classes, virtual practical components, and classroom interactivity as being critical in maintaining student interest [33], which must be accommodated into a new structure, along with institutionalizing interim innovations. TVET programs contributed greatly during the pandemic, serving as spaces for the production of needed goods, such as masks and PPE. They also hold great potential in the future to re-skill populations, especially those who suffered economic losses, such as migrant labor, towards emerging fields such as technology and health allied fields [6].

5. Evaluation for TVET

TVET evaluation can follow an outcome-based or process-based approach. The outcome-based approach focuses on the resultant employment after formal training, and includes measurable factors such as the number of teachers and trainers employed, ongoing projects, and degrees awarded. To account for the qualitative aspect of knowledge and skills imparted, the process-based approach incorporates the feedback of students and teachers, qualifications of trainers, and translation of theoretical knowledge into practical projects by assessing on-ground impact. The role of employers as social partners, the individual contribution of all stakeholders, and relevant social nuances such as equitable opportunities and awareness amongst and participation of all genders, need to be ensured. SMART (Specific, Measurable, Achievable, Realistic, and Timely) indicators may be developed to study the intricacies of the underlying processes for higher efficacy [34–36]. Additionally, terms of "evaluation", "innovation", and "quality" need to be concretely defined as a basis for provisions and potential amendments in the system accordingly. As reflected by the UNESCO–UNEVOC repository (2021) [7], the German National Qualifications Framework aims to promote lifelong learning by assessing learning outcomes and evaluating competencies in professional (knowledge and skill) and personal (social competence and autonomy) domain. Internal and external quality assurance has been in place since 2004 for all TVET providers, with the Federal Ministry of Economics and Technology responsible for setting criteria for the same. The well-renowned Finnish TVET

model was revised to meet the requirements of skills in the evolving industrial sector by increasing edtech and incorporating personalized updated learning pathways [7,37]. High quality is assured by government monitoring and external evaluations carried out by Finland's National Education Evaluation Centre in order to regularly check the effectiveness of quality education.

6. Limitations

This paper is restricted to suggesting measures to improve the TVET structure in India, using model examples from Germany and China. The point of view of students in TVET, especially during the global health emergency of COVID-19, does not seem to be adequately captured in the available literature. As a crucial indicator for determining the success of TVET programs, this needs to be afforded due importance. Further research in this regard should therefore be carried out.

7. Conclusions

As suggested by the literature, India has reported numerous obstacles in the TVET system, which have worsened due to the global pandemic. The major challenges include passive participation of students, the resultant gap between theoretical and practical education, a lack of infrastructure for centers, poor coordination amongst agencies and between stakeholders, outdated syllabi, and minimal use of recent technologies. The absence of a legally binding framework to set regulations and ensure effective execution of the same further accelerates the problem.

As a result of the health emergency, state and nationwide lockdowns resulted in the digitization of the entire education system and restrictions in on-ground training. A significant number of vocational trainees were unable to access sessions, owing to the digital divide and geographic constraints, and were further discouraged. The exposed gaps pertaining to the use of technology by teachers and issues faced by the students, including difficulties in coping with the online learning mode and limited physical interactions, exacerbated these concerns, especially in the long term view.

Possible improvements in performance were assessed along eight parameters: stakeholder involvement, active student engagement, industry-school education, incentive structure, technology use, and a decentralized system. Germany's "dual" model and China's "modern" system were found to be robust, and were well equipped to tackle the impact of the pandemic on the TVET sector, while India lacked proper development in these aspects, resulting in barriers to continual education. The significant progress made by these two countries to strengthen TVET offers possibilities for India to adopt similar holistic changes to its system, to ensure quality education and low unemployment rates.

Given the rural–urban divide and gender specific barriers, social equity in this sector is evidently lacking, and suitable policy measures need to account for this, while ensuring a righteous basis of provision of opportunities. That is to say, figures depicting equal representation of males and females, or narrowing geographic gaps, must not be at the cost of the quality of education or experiential learning delivered to them.

Further, methods to incorporate a process-based approach to evaluation must be improved upon. This would broadly consist of the eight parameters, as discussed above, following SMART indicators for effective results. A greater focus would therefore need to be placed on individual and collective learning beneficial for overall development, than on final results that subdue the very essence of quality education in sustainable practice. Thus, in order to mitigate existing challenges, the models of Germany and China may prove beneficial if adopted in India, helping to refine its TVET structure and become more resilient to the changing new world scenario.

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Proceeding Paper

Let's Talk about MPAs: Blue Spaces in Africa—Case of RAMPAO †

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Abstract: The RAMPAO: 'le reseau regional d'aires marines protégées (AMP) en Afrique de l'Ouest' (the regional network of marine protected areas (MPAs) in West Africa) covers two million marine and coastal hectares; there are more than 27 sites which are protected members of this network, through protection of species which occurs in different marine territories where the network actively operates. The RAMPAO was officially created within the framework of the implementation of this regional strategy. The establishment is the result of joint efforts responding to the various recommendations and international commitments taken by them as part of biological conservation.

Keywords: RAMPAO; MPA; West Africa; marine area; conservation; biodiversity

1. Introduction

The term MPA (marine protected area) was first used in 1954 in London at the International Convention for the Prevention of Hydrocarbon Pollution of Marine Waters. Following this day, governments and communities became aware of the need of biodiversity conservation.

MPAs are defined by the regions at sea whose goal is to conserve and safeguard marine organisms that are considered sensitive or of biological significance.

They have been tools of maritime defense since that time. At the start of the 2000s, their global population has been growing [1].

The existence of pro-connected pooling networks characterizes West Africa's western coastline zone [2].

These are cold ascending currents that rise to the surface, carrying nutrients that are normally present exclusively on the seafloor [3]. This phenomenon is accompanied with fluviatile inputs rich in sediments from the Senegal and Gambia rivers, which flow into the same location. Because of the confluence of these two criteria, this coastal area is classified as an ecoregion or an unusual geographical location due to its unique characteristics.

It is critical to consider this area as an ecological continuity that extends beyond the territorial or political boundaries of the marine protected area, simply because migrations of birds from the northern hemisphere or the circulation of schools of fish contribute punctually to enriching this environment; thus, taking seasonal migrations of species into account is essential [4].

Overexploitation of fish resources for commercial reasons is one of the dangers. This pressure will have the unintended consequence of disrupting the food chain.

Because of its popularity and influence, it is a grand example of how biodiversity protection may be boosted. Furthermore, it is particularly essential that local people utilizeit to safeguard their ancestors' lands.

The RAMPAO is a structure that protects two million marine and coastal hectares; there are over 27 protected members of this network, which protects species found in diverse maritime locations where the network is active.

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RAMPAO has significantly contributed to the improvement in MPA management efficiency over the last ten years, including, among other things, the networking of a set of representative MPAs, the rehabilitation and preservation of certain wildlife species, the interchange and mutual learning of network members, and the rehabilitation and restoration of certain critical habitats, as well as assistance for functional MPAs that achieve the conservation objectives that have been allocated to them.

2. Background of the RAMPAO

Indicating the prevalence of migratory species, shared transboundary habitat resources, and the mobility of users, notably fishermen, in the subregion, marine and coastal conservation stakeholders rapidly recognized the need to address coastal zone and resource management at the subregional level [5]. To ensure the protection of the structure and functions of marine and coastal ecosystems at the regional level, a collaborative approach is required (Jennings, 2004).

The various groups of stakeholders engaged created a regional strategy for MPAs in 2002. The shared goal is a cohesive network of marine protected areas in West Africa, maintained by strong institutions in a participatory way that appreciate natural and cultural diversity in order to contribute to the region's sustainable development [6].

Through the signature of a general policy declaration by 10 ministers in responsibility of the environment, protected areas, and fisheries in seven countries in 2003, this regional plan swiftly gained considerable support from the political authorities of the nations concerned (Cape Verde, Gambia, Guinea-Bissau, Guinea, Mauritania, and Senegal).

The Regional Network of Marine Protected Areas in West Africa (RAMPAO) was officially established in Praia, Cape Verde in 2007 as part of the execution of this regional plan. RAMPAO was therefore established as a consequence of the combined efforts and desire of the subnational regions and regional actors, while reacting concretely to the numerous international recommendations and promises made by the states in the context of biological conservation.

RAMPAO obtained official recognition from the authorities of the seven states in 2010 through the signing of a declaration of formal recognition of the network by fifteen ministers, allowing it to establish the network's institutional credibility and promote its value as a contribution to the implementation of the states' international commitments [7].

Several studies on the network's institutional, organizational, and financial autonomy were undertaken in 2015, acknowledging the necessity to strive toward its institutional, organizational, and financial autonomy [2]. Following their deliberations, the network members decided to form a foreign association under Senegalese law and devised a timeline to finish the formation procedure.

RAMPAO has significantly contributed to the development of MPA management efficiency over the last 10 years, including, among other things, the networking of a set of representative MPAs and the rehabilitation and restoration of specific important habitats, the sharing and mutual learning of network members, as well as support for functional MPAs that achieve the conservation objectives that have been set to them [3].

3. The benefits of RAMPAO

RAMPAO's contributions to the conservation of West African marine protected areas may be divided into two categories [3].

Social benefits: Individuals and the gathering of capacities of managers of marine protected areas benefit socially in a variety of ways, including the development of management plans, the development of business plans, marine surveillance, shared governance, exchanges, mutual reinforcement, economies of scale in terms of training, and meetings, collaborating on obstacles and making progress in a group setting.

Ecological advantages include: the network's coverage of two million marine and coastal hectares, the protection of more than 27 sites and network members, the preservation of species that grow in diverse maritime areas where the network is active, and the

movement of species. The network allows for the preservation of a sample of the ecosystem, as well as the defense of multiple samples of the same ecosystem.

A network must satisfy four requirements, according to the US Interdisciplinary Partnership on Ocean Coastal Studies:

- It must have adequate connection;
- It must be consistent with conservation aims and (species, habitats, heritage, etc.);
- It must be reflective of the diversity of species and habitats, as well as of the ecosystem;
- Conservation objectives (species, ecosystems, heritage . . .) should be representative of the range of settings experienced, and have a strong conservation return based on costs and activities in balance.

The West African maritime eco region extends over 3500 km of coastline and now includes seven nations, and faces a variety of difficulties (See Table 1 and Figure 1).

RAMPAO is made up of national parks, nature reserves, community marine protected areas, wetlands, wildlife sanctuaries, and indigenous and community heritage areas.

The areas of community and indigenous heritage are more than thirty MPAs have been established throughout the subregion in the previous two decades with the assistance of states and non-governmental organizations (NGOs). Protected fishing areas (zones de pêche protégée—ZPP) are another form of MPA in Senegal, beside with artificial reef immersion zone (ZIRA), regulated exploitation zone, no-take zone, and zone of fishing, which were established in Senegal under the PRAO project (Regional Fisheries Program in West Africa). These MPAs are distinguished by a co-management governance model (Failler et al., 2018).

In 2009, the regional network of marine protected areas (MPAs) in West Africa (RAMPAO) included 19 MPAs from 4 countries out of the 24 officially recognized MPAs in 6 of the 7 countries of the West African marine ecoregion.

In 2015, part of the seven nations' territorial seas were protected owing to the RAMPAO's 32 MPAs, which covered an area of 2,188,826 hectares (see Table 2 below).

In 2018, RAMPAO included 32 officially recognized MPAs in the western African marine ecoregion [1].

RAMPAO is made up of National Parks, Nature Reserves, Community Marine Protected Areas, Wetlands, Wildlife Sanctuaries, and Indigenous and Community Heritage Areas.

Table 1. RAMPAO Members (See: Figure 1).

Members	Official Name	MPAs
Cape Verde	Republic of Cape Verde	- Natural Reserve of Costa De Fragata - Natural Reserve of Tartaruga - Baia De Murdeira Nature Reserve - Santa Luzia Integral Reserve
Gambia	Republic of the Gambia	- Niumi National Park - Tanji and Bijol Island Shoreline Reserve - Bao Bolong Wetland Reserve - Tanbi National Park - Bolong Fenyo Community Wildlife Reserve
Guinea	Republic of Guinea	- Tristao Islands Managed Nature Reserve - Loos Islands Wildlife Sanctuary - Alcatraz Strict Nature Reserve - Rio Kapatchez Managed Nature Reserve
Guinea-Bissau	Republic of Guinea-Bissau	- Rio Cacheu River Mangrove Natural Park - Orango National Park - João Vieira-Poilão National Marine Park - UROK Community Marine Protected Area - Cantanhez National Park

Table 1. *Cont.*

Members	Official Name	MPAs
Mauritania	Islamic Republic of Mauritania	- Banc D'Arguin National Park - Cap Blanc Satellite Reserve - Diawling National Park
Senegal	Republic of Senegal	- National Park of The Barbary Tongue - Madeleine Islands National Park - Saloum Delta National Park - Popenguine Nature Reserve - Bamboung Community Management MPA - Kayar MPA - MPA Joal-Fadiouth - MPA Saint Louis - Abéné MPA - Kawawana Community Native Heritage Area - Palmarin Community Nature Reserve - La Somone Nature Reserve of Community Interest - Gandoul MPA - Niamone Kalounayes MPA - Kassa-Balantacounda MPA - Sangomar MPA - APAC "KapacOlal De Mlomp"
Sierra Leone	Republic of Sierra Leone	Yawri Bay

Source: RAMPAO Official Website.

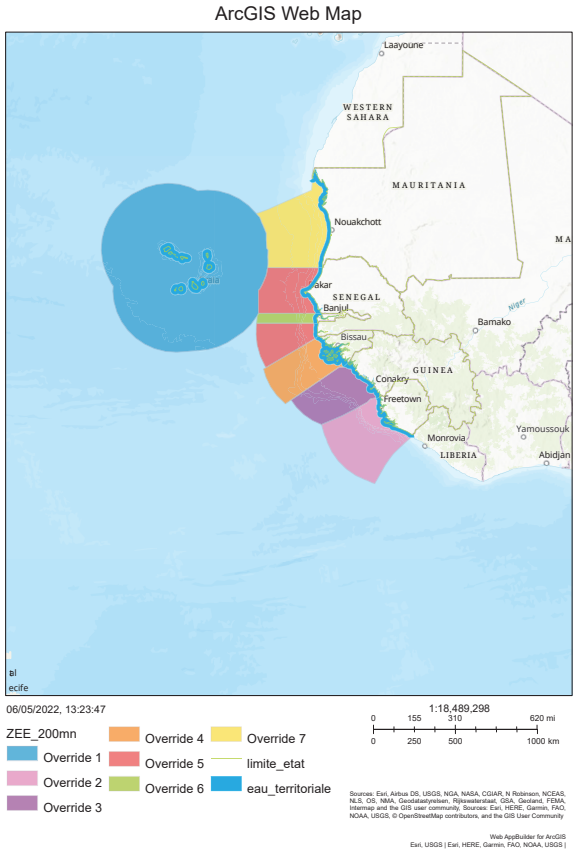

Figure 1. Location of MPAs in the West African marine ecoregion. **Sources:** Esri, Airbus DS, USGS, NGA, NASA, CGIAR, N Robinson, NCEAS, NLS, OS, NMA, Geodatastyrelsen, Rijkswaterstaat, GSA, Geoland, FEMA, Intermap and the GIS user community, **Sources:** Esri, HERE, Garmin, FAO, NOAA, USGS, © OpenStreetMap contributors, and the GIS User Community.

Table 2. Evolutionof the protected area and the number of MPA members of the RAMPAO.

Year of Membership RAMPAO	Number of MPA Members	Additional Area (ha)
2007	15	1,641,774
2008	1	104,767
2010	7	126,664
2011	4	174,487
2013	1	700
2015	4	140,324
Total	32	2,188,826

Source: Failler et al., 2018.

4. RAMPAO's Activities and Objectives

The goal of RAMPAO's strategic orientations and work plan is to support, in a sufficient and harmonic manner, the efforts made by RAMPAO's many actors to enhance the coherence and functionality of the network in order to accomplish the specified objectives.

At the official website, (https://www.rampao.org/Nos-activites.html?lang=fr (accessed on 2 September 2021)) of RAMPAO, we encountered that the current 2020–2024 work plan has been focused on consolidating the network's successes and development since its inception in 2007, specifically on: increasing the efficacy of MPA administration; institutional and financial strengthening of the network; and the services provided to its members.

- To guarantee: the collaboration of a coherent set of MPAs representative of critical ecosystems and habitats required for the dynamic functioning of environmental processes essential for the regeneration of marine and coastal natural resources, the rehabilitation and reconstruction of critical habitats, and the preservation of biodiversity;
- The maintenance and sustainable use of the West African maritime and coastal ecoregion's biodiversity and ecosystem services, as well as its heritage, natural, and cultural resources, for the benefit of the region's people, particularly local communities, via a functional regional network of MPAs.
- Support: networking and synergies between managers on the one hand, and managers and other technical players involved in the administration of MPAs in the region on the other.
- The promotion of exchange and mutual learning among association members and other actors involved in the management of MPAs in the region, activities likely to make the region's MPAs more functional and operational in the long term;
- Ensuring connectivity and resilience, particularly in the face of climate change impacts;
- Increasing knowledge of the ecological and socioeconomic importance of the region's MPAs and the biological resources they contain, as well as ways and means of fairly and equitably sharing the benefits of their use, particularly with local populations;
- Promotion of the establishment and inclusion of additional MPAs in the region's network.

5. RAMPAO's SWOT

According to [3], the health status of the network's protected areas is one of the network's biggest strengths. They are home to numerous animal and plant speciesanda diverse range of environments.

The major opportunity is, above all, the subecological region's riches. This wealth must be increased and protected. Within their limits, protected zones provide excellent protection. Within their bounds, they provide protection.

Reasoned eco-tourism might aid in the strengthening of local capacities in the face of external demands. The primary risks are many and dispersed. As a result, precisely isolating them is challenging. Managers of maritime protected zones are concerned about industry, oil extraction, and fishing.

Natural dangers are also significant. The table on the next page goes into further information about the key items gleaned from the surveys.

Strengths

- Healthy protected areas overall;
- Legal framework to build on;
- Good involvement of local populations;
- Effectiveness and enforceability of protection measures;
- Subregional approach;
- Present existence of entities and partners;
- Working for the promotion of MPAs (RAMPAO, PRCM, NGOs, international cooperation . . .).

Weaknesses

- Low MPA budget;
- Low human capacity;
- Lack of infrastructure;
- Institutional instability;
- Instability of MPA funding;
- Lack of basic knowledge (habitats, key species, basic MPA of the MPAs, scientific studies . . .);
- Communication still in need of improvement;
- Volunteers are not valued enough;
- Gaps in coherence, connectivity, and representativeness of the network.

Opportunities

- Biological richness of the subregion;
- Beneficial effects of MPAs;
- Important tourist potential;
- Organized and motivated partners acting at the scale of the subregion (PRCM, RAMPAO, NGOs, international cooperation . . .);
- Margin of progression of the network;
- RAMPAO is an interesting lobbying tool for the promotion of the network.

Threats

- Increase in the pressure;
- Anthropic pressure (demography, agriculture, extraction of natural resources . . .);
- Physical phenomena: erosion, invasive species . . . ;
- Phenomena accelerated by climate change and human activity;
- Increasing exploitation of fishery resources;
- Poverty of the populations;
- Lack of environmental awareness on the part of the population;
- Pollution: offshore oil exploitation.

The proposal, dated 5 July 2021, emphasizes a 2050 vision and a 2030 objective, specifically, "By 2050, biodiversity is appreciated, preserved, restored, and intelligently exploited, preserving ecosystem services, sustaining a healthy world, and delivering benefits important for all people." The draft frameworks state that there will be "urgent action across society to conserve and sustainably use biodiversity and ensure the fair and equitable sharing of benefits from the use of genetics resources, to put biodiversity on a path to recovery by 2030 for the benefit of planet and people" in the period up to 2030.

The 17 sustainable development goals are the centerpiece of the 2030 Agenda for Sustainable Development. The 17 goals cover almost all important development themes, including access to education, clean water and renewable energy, infrastructure, industry, agriculture, biodiversity protection, and climate change.

At the United Nations Summit in New York in September 2015, world leaders endorsed "The 2030 Agenda for Sustainable Development." The agenda gives the world a fresh push and direction for moving toward a more sustainable and resilient future. Its 17 sustainable

development goals (SDGs) aim to strike a balance between the economic, social, and environmental aspects of development. They want to spur action in areas that are vital to the world and humanity during the next 15 years [8].

In this sense, and according to the SDG, the RAMPAO objective is the conservation and sustainable use of biodiversity and ecosystem services as well as the heritage, natural, and cultural resources of the marine and coastal ecoregion of West Africa for the well-being of the populations of the region, by particularly local communities, through a functional regional network of MPAs.

6. Conclusions

RAMPAO was established as part of the West African Regional Program for the Conservation of the Marine and Coastal Zone. The goal of this network is to link together the existing maritime protected areas, both biogeographically and humanly: to bring together the administrators of these marine protected areas to debate the issue and to conserve this network as best as possible [8].

It is a network that has given itself the goal of preserving coherent ecosystems that are critical for the operation of ecological processes in order to protect biodiversity and safeguard the legacy and services of related ecosystems [6].

It is a network that aims to reach seven West African countries: Mauritania, Senegal, Gambia, Guinea-Bissau, Guinea Sierra Leone, and the Cape Verde Islands.

This network is the result of a long-term effort and was created to put an end to similar problems that marine protected areas face, because they face the same challenges in terms of conservation of marine and coastal resources. They share trans-boundary habitats, crossing of marine borders by marine spaces, and a concerted approach to be able to face all of these problems; and from there, RAMPAO was born.

From 2004 to 2007, ongoing meetings were on the schedule to reflect on the network's functioning and aims, culminating in 2007 with the network's official establishment as such during its consultative assembly in Cape Verde.

A regional plan for marine protected areas was created in 2002, prompting political recognition and interest from the Ministers of Fisheries and Environment of the nations involved, who signed a policy statement emphasizing the relevance of this network.

All of these benefits are obviously transferable to RAMPAO. The major advantages now are precisely the social ones. The cohesiveness between the many managers of West African MPAs, national institutions, and foreign partners has improved. Members' exchange visits have been carried out [9].

These proved to be fruitful and satisfying for the participants.

Local communities are better heard, and the formation of mixed-management committees allows everyone to be heard. The network has produced substantial synergies between MPAs and among the network's partners. A similar scenario has been found in the Mediterranean MPA network [10].

Furthermore, MPAs with low visibility benefit from the RAMPAO, the centralization of data, and data and information enable for an examination of documents at the network size. RAMPAO has one of these responsibilities.

This endeavor stimulates the generation of knowledge, and this job promotes knowledge creation and identifies gaps in fundamental understanding about marine and coastal species, as well as coastal species and ecosystems in the subregion. Benefits are also flowing to the network's member managers at the operational level. They may, indeed, count on logistical and financial help [10].

The Secretariat of the Small Grants Program encourages conservation actions and allows managers to carry out certain costly measures.

Finally, one of the axes on which the secretariat has been working for a long time is the strengthening of the capacities of network members through, among other things, papers for managers [11].

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Network Science Tools Reveal System-Level Properties of SDG Interlinkage Networks †

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Abstract: A growing literature constructs SDG interlinkage networks in order to understand the interplay between goals, co-benefits, and trade-offs present in Agenda 2030. Networks are constructed from a variety of sources including historical correlations, expert analysis, and literature surveys. However, beyond simply constructing such interlinkage matrices, it is important to explore their implications and to compute quantities that describe the system-level response of the network so that we can shed light on the overall network structure and its implications for policy decisions. In this paper, I review fundamental ideas of centrality and hierarchy that may prove useful in these system-level analyses, and I illustrate the ideas on two specific SDG interlinkage networks. Missing data is particularly problematic in such analyses, pointing to the ongoing need to improve data collection on the SDGs. In terms of the results for the specific SDG interlinkage networks that I consider, the network analyses reveal an asymmetry between the support for SDGs 1, 2, and 3 that the remaining goals provide, and a lack of influence in the other direction from SDGs 1, 2, and 3 to the other goals. These are much harder to observe in the absence of such system-level methodologies. In particular, the analyses highlight the possible lack of integration of SDGs 14 and 15, which may point to the need for additional policy interventions to support progress on these two goals in particular.

Keywords: complex network; centrality; hierarchy; mathematical modelling; policy coherence; synergy; trade-off

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1. Introduction

Systems thinking provides a flexible bridge between quantitative and qualitative insights into complex phenomena. On the quantitative side, the last two decades have seen rapid growth in the analysis of complex networks and the development of new tools and methods that reach across scales to show how system-level outcomes result from local interactions.

Interlinkage networks for the Sustainable Development Goals [1] reflect the premise that progress on one SDG should influence (positively or negatively) progress on other goals [2]. For example, the seven-point scale proposed by Nilsson, Griggs and Visbeck [3] describes influences between goals in terms that include 'reinforcing' and 'enabling' for positive linkages, and 'constraining' or 'counteracting' for negative interlinkages. Behind this sits, implicitly or explicitly, a sense of the scope of likely, or perhaps merely possible, policy actions and the effects that a policy action aimed at one SDG might have on others, either for better (a 'co-benefit') or worse (a 'trade-off').

In network science terms, these indirect effects of policy actions form a network that is directed and weighted (allowing different interactions have different strengths). Moreover, unlike, for example, disease transmission networks, linkages can be negatively weighted, corresponding to trade-offs between goals rather than the co-benefits described

by positive links. Such networks are typically constructed either from expert analysis, literature surveys, or by analysing correlations in timeseries for SDG indicators.

In this short paper, I explain and apply two sets of ideas from network science to interlinkage networks derived from goal-level interactions. The first, which I discuss in Section 2, is the idea of eigencentrality [4–6] which formally does not apply to complex networks with both positive and negative links, but, as has been shown previously, has an alternative and extremely useful interpretation, making it an important system-level statistic [7].

Section 3 discusses the second idea: the notion of hierarchy among the SDGs. Measures of overall hierarchy and directionality in complex networks have their roots in the computation and analysis of ecosystems, for example, food webs, but lend themselves also to the systemic analysis and quantification of prioritisation between the SDGs. Prioritisation of SDGs that lie further 'upstream' of others should enable those goals to be met while at the same time allowing benefits to flow through the network and, thus, allowing the whole system to benefit. In contrast, prioritisation of SDGs that lie far 'downstream' and, hence, have much lower levels of influence on other goals would not allow all SDGs to be met. I develop and discuss measures of hierarchy that help to identify points of leverage and maximum 'downstream benefit' to other goals in the network.

Section 4 presents results that test these ideas on a range of interlinkage networks using data from reports including the 2015 report published jointly by the ICSU and ISSC [8] and the Global Sustainable Development Report 2019 [9,10]. I present conclusions in Section 5.

2. Centrality Measures

Throughout the paper, we consider a network containing n nodes (and, in the case of the SDGs, usually $n = 17$) and a set of directed edges with either positive, negative, or zero weights given by the n-by-n adjacency matrix A. In the mathematical notation that follows our convention is that matrices are denoted by capital letters, not in bold, while vectors are denoted by lowercase bold letters. Elements of matrices and vectors are indicated by subscripts. The entry A_{ij} is defined to be the weight of the edge from node j to node i, i.e., the influence of node j on node i. A common observation in network science is that some nodes appear to be more important or more 'central' to the network than others. The most fundamental notion of centrality is just to count the number of other nodes to which a node is connected. This gives rise to the centrality measures,

$$k_i^{in} \sum_{j=1}^{n} |A_{ij}| \text{ and } k_i^{out} \sum_{j=1}^{n} |A_{ji}|,$$

which are the (weighted) in-degree and out-degree of node i, respectively. The absolute value is required in order to avoid cancellation if a node has both positively and negatively weighted edges connected to it. Pham-Truffert et al. [11] referred to nodes that have a large in-degree as 'buffers' since they serve to combine the effects of many different nodes together, and to nodes that have a large out-degree as 'multipliers' as they serve to propagate the influence of a node to many other parts of the network. The total degree $k_i = k_i^{in} + k_i^{out}$ is a natural measure of the relative importance of node i in the network: this is the degree centrality of the node.

While simple, the concept of degree centrality can be criticised for its purely local nature; it counts the numbers of direct neighbours of a node but does not make any allowance for how connected those nodes themselves might be. A more robust measure of importance could, therefore, be obtained differently, through a slightly self-referential definition: the importance of a node is given by the weighted sum of the importance of the nodes to which it is connected. Mathematically, this implies that the importance v_i of node i is given by

$$v_i = \frac{1}{\lambda} \sum_{j=1}^{n} A_{ij} v_j, \tag{1}$$

where λ is a weighting parameter. This definition appears to be slightly circular since it demands knowing the importances v_j of the nodes j to which node i is connected. One can imagine an iterative scheme, starting with estimated values for the v_i and then recalculating them according to the formula until they converge. Such an approach works and gives the same answer in fact as the more mathematical approach which is to multiply up by the factor of λ and to consider the equation $Av = \lambda v$, which is well known as the equation defining the eigenvectors v and eigenvalues λ of the matrix A. Generically, A has n distinct eigenvalues $\lambda_1 \ldots \lambda_n$ each with a corresponding eigenvector $v_1 \ldots v_n$. The eigenvalues are labelled in order, so that $Re(\lambda_1) \geq Re(\lambda_2) \geq \ldots \geq Re(\lambda_n)$, where Re denotes the operation of 'taking the real part of' for a possibly complex eigenvalue λ_i. For a matrix A that has non-negative entries, the largest eigenvalue λ_1 is guaranteed to be real and non-negative, and its corresponding eigenvector v_1 can be chosen so that it is non-negative as well; this is the Perron–Frobenius theorem. When the weighting parameter λ is fixed to be larger than λ_1 the iterations of Equation (1) converge to zero, which gives no information about centrality; reducing λ so that iterations of Equation (1) converge to a nonzero solution results in convergence to the (leading) eigenvector v_1 and, hence, to a meaningful answer. The elements of this 'leading' eigenvector are then a centrality measure which describes the relative importance of each of the nodes; this is known as eigenvector centrality, abbreviated sometimes to 'eigencentrality'. For the SDGs, the meaning of eigencentrality can be intuitively related to the rate at which progress on other SDGs reinforces and drives progress on each SDG itself, as I now discuss in a slightly more general setting that copes with a larger class of interaction matrices that contain negative as well as positive interlinkages.

While the above is mathematically well defined only for non-negative matrices, it is often the case that a network with only a relatively small number of negative links will also have a leading eigenvector that has all entries non-negative; in such a case, it is tempting to continue to interpret the leading eigenvector as a centrality measure. But there is an additional context for interpreting the leading eigenvector: it is the dominant 'response' of the network when considered as a dynamic problem, evolving the state of the nodes over time. In the simplest possible case, consider the evolution equation

$$\frac{dx_i}{dt} = \sum_{j=1}^{n} A_{ij} x_j, \tag{2}$$

where the rate of change of the state variable x_i associated with node i depends linearly on the state variables at the nodes connected to i, mediated by the strength, direction, and sign of the interaction between the two nodes as captured by the interlinkage A_{ij}. The solution to Equation (2) is dominated, apart perhaps over a short initial transient phase, by the form of the leading eigenvector since it corresponds to the mode of maximum growth rate; the eigenvalues $\lambda_1 \ldots \lambda_n$ are the growth rates of these different modes of response, but v_1 dominates since (by definition) λ_1 is larger than all the others. In the interest of simplicity, I ignore the case where the two largest eigenvalues are real and equal, because this is generically unlikely to happen; moreover, it is observed not to be relevant to cases in practice such as the examples below, where the leading eigenvalue is clearly separated from the remaining $n - 1$ eigenvalues.

Hence, the leading eigenvector can be interpreted as the intrinsic mode of self-reinforcing growth of the state variables $x_1 \ldots x_n$ caused solely by their interactions. In the context of this work, and conscious of many caveats around the simplistic nature of Equation (2) and the coarse-grained representation this implies, $x_1 \ldots x_n$ can be viewed as the relative levels of progress made on each of the SDGs, interpreting the interlinkages as these reinforcing or balancing effects due to policy actions. This is aligned with the analysis of cross-impact matrices by several authors including notably Weitz et al. [2], who described their cross-impact matrix as attempting to address the question: *"If progress is made on target x, how does this influence progress on target y?"* In summary, large positive

values of eigencentrality for an SDG indicate that progress on this SDG is well supported by progress on others, whereas smaller or negative values show that progress on this SDG is not an inevitable outcome of progress elsewhere and, hence, may deserve specific policy interventions.

3. Hierarchy in Directed Networks

Building interlinkage matrices with directed edges between nodes, rather than undirected ones (which would be interpreted as either mutually beneficial or mutually antagonistic relationships only), immediately leads to questions at the system level as to whether the network taken as a whole has a sense of directionality to it. The answer may be that it does not, for example, as would be the case of a network consisting of a cyclic ring of directed edges: all nodes have the same 'level' in the network. Contrastingly, a chain of positive directed edges all pointing in the same direction confers a clear hierarchy since, in our SDG context, progress on SDGs corresponding to nodes earlier in the chain results in co-benefits shared with SDGs further along the chain, but the reverse is not true.

In the context of the SDGs, it is clear that, while progress on goals related to societal change such as SDG 5 (gender equality) and SDG 10 (reduced inequalities) are highly likely to lead to progress on 'human development' goals such as SDG 1 (no poverty) and SDG 3 (good health and wellbeing), it is not so clear that all policy actions taken to reduce poverty or to improve healthcare would necessarily have co-benefits that included progress on SDG 5 or SDG 10; the progress on SDG 1 or SDG 3 could be a result of policy that failed to address persistent inequalities in gender or other population characteristics. So, how could we decide whether a given interlinkage network implies the existence of a hierarchy, and, if it does, how can we find which of the SDGs comes further up and which is lower down in the hierarchy that the directed network implicitly generates?

Following MacKay, Johnson, and Sansom [12], we can attempt to understand the extent to which a network has a hierarchy by assigning a level h_i to each node i, and looking to minimise a function F of the levels that measures the overall amount of directionality in the network. MacKay, Johnson, and Sansom referred to this quantity as the 'trophic confusion' in the network, motivated by food webs where the structure of the trophic network is a key quantity of interest in order to understand an ecosystem. A generalisation of their initial idea is to include a collection of prespecified quantities g_{ij}, not necessarily related to the adjacency matrix entries, which provide a set of target spacings between the levels h_i. The values of the levels h_i that minimise F can be determined by minimising the function

$$F(h) = \frac{\sum_{ij} |A_{ij}| \left(h_i - h_j - g_{ij}\right)^2}{\sum_{ij} |A_{ij}|}. \tag{3}$$

The form of $F(h)$ in Equation (3) guarantees that it is non-negative and has minimum value zero when the spacings between levels satisfy exactly the requirements given by the g_{ij}. The denominator provides a normalisation of the values of F, enabling comparisons between different networks if the distribution of edge weights is the same; otherwise, it does not affect the values of h that minimise F. Equivalently, the levels h_i that minimise F are given by solving the equation

$$\Lambda h = vecdiag\left(AG^T - A^T G\right), \tag{4}$$

where the matrix $\Lambda := diag(k) - A^T - A$, the operation $vecdiag()$ extracts just the elements of the main diagonal of the matrix and forms these into a column vector, k is the vector of total degrees as defined previously above, G is the matrix whose entries are the target spacings g_{ij}, and the notation $diag()$ forms a square matrix with the elements of the vector as the main diagonal of the matrix, with zeros elsewhere. In the case $g_{ij} = 1$ for all i and j, the right-hand side $vecdiag\left(AG^T - A^T G\right)$ reduces to the difference between the (weighted) in-degree and out-degree.

Despite this rather detailed set of definitions, minimising the 'trophic confusion' quantity F is straightforward to implement computationally and provides a representation of a network that as far as possible provides an overall sense of directionality. This enables a visualisation of which nodes are furthest 'upstream' in the network and so influence most others, and which are furthest downstream and hence benefit most from co-benefits due to other SDGs.

4. Examples

To illustrate the concepts in the previous two sections, I analyse two interlinkage matrices for the SDGs at the goal level. The first of these was generated from an expert analysis [8] conducted by the International Science Council in 2015, when it was still the International Council for Science (ICSU), in partnership with the International Social Science Council (ISSC); I therefore refer to it as the ICSU Report. Although it is based on a qualitative analysis of policy interlinkages rather than historic data, this is one of the few reports to treat all the SDGs (except SDG 17 on partnerships for the goals) identically. Dawes (2020) [7] described in detail the methodology through which the expert opinions were turned into a quantitative cross-impact matrix. Essentially this involved interpretation of the direction of interlinkages from the report's text, combined with an indication of the strength of an interlinkage given by the number of targets in the SDG that was being influenced that were mentioned as being impacted by progress on the influencing SDG.

The second interlinkage matrix considered is the one produced as part of the Global Sustainable Development Report (GSDR) 2019 [9–11]. This report carried out a literature survey of 177 global scientific assessments, UN flagship reports, and scientific articles on SDG interlinkages, wherever possible looking at the level of targets; here, their results are considered after aggregation to the goal level. A hand-coding of statements in these articles resulted in a set of 4976 separate positive and 782 negative interactions. Although there is considerable value in preserving the distinction between the positive and negative interactions separately, as discussed in more detail elsewhere [13], in this paper, for reasons of brevity, I discuss only the 'net interlinkage' matrix, adding positive and negative interlinkages together.

Figure 1 shows the interlinkage matrices derived from the ICSU and GSDR reports. Interlinkages are scaled to lie in the range $[-1, 1]$, and those close to zero are replaced by whitespace to improve the readability of the figures. Diagonal entries are removed from the GSDR matrix to make this more directly comparable with the ICSU matrix; removing these entries turns out to have only a very minor effect [13]. In both cases, we observe that almost every SDG influences SDGs 1–3, as shown by the densely populated top three rows of each plot. But there are fewer influences from SDGs 1 to 3 on the remaining goals, as is shown by the relatively sparsely coloured first three columns on the left-hand side of each plot. This highlights a fundamental asymmetry in Agenda 2030: the first three SDGs are those on which most attention is focused, with SDGs 4 to 17 in some sense playing a subordinate role, supporting the fundamental development agenda and continuation from the Millennium Development Goals that SDGs 1–3 represent.

It is numerically straightforward to compute the eigenvalues and leading eigenvectors for the interlinkage matrices shown in Figure 1; the results are given in Figure 2. Figure 2a plots the eigenvalues in the complex plane. In both cases, there is a leading eigenvalue that appears far to the right of the remaining ones, leaving a significant gap between the leading eigenvalue and the next largest, for both the ICSU eigenvalues (red squares) and GSDR eigenvalues (black dots). This indicates that the domination of the behaviour of the networks by their leading eigenvectors is robust to perturbations of individual interlinkages. Detailed sensitivity analysis was carried out elsewhere [13]. The form of the leading eigenvectors themselves is shown in Figure 2b, again with GSDR eigenvectors in black and the ICSU ones in red. The lines joining the dots are just a guide to the eye; the data points show the components of the eigenvectors for each of the SDGs. The ICSU eigenvector has only 16 components since the ICSU analysis omitted SDG 17 completely.

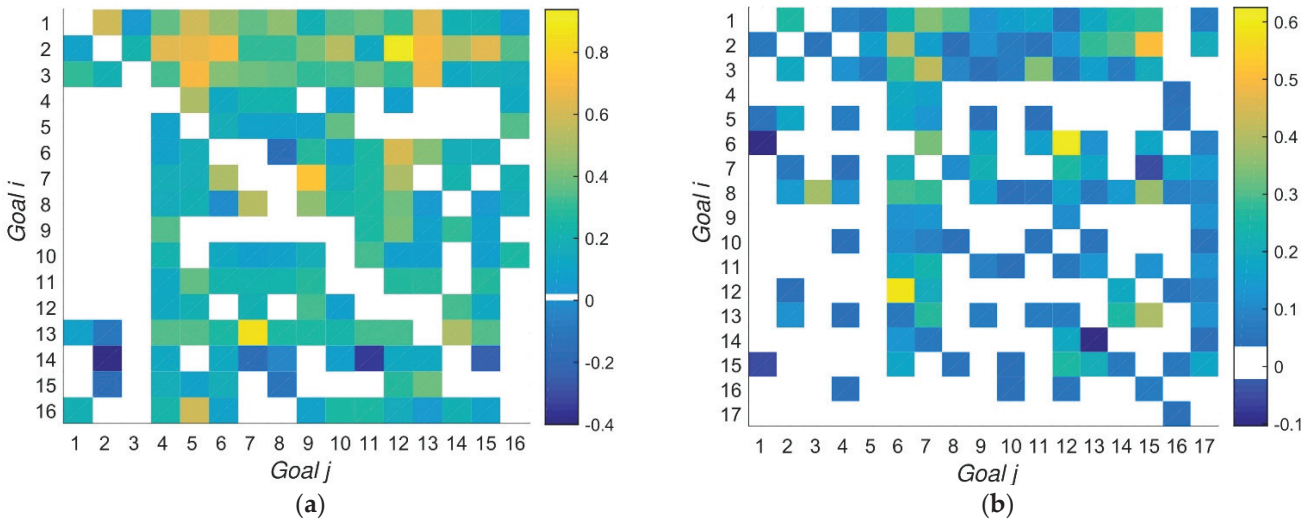

Figure 1. Heatmaps showing the distribution of positive and negative interlinkages in the SDG interaction matrices used as examples here. (**a**) The 16 × 16 ICSU matrix (SDG 17 was omitted from their analysis); (**b**) the 17 × 17 GSDR 2019 interlinkage matrix. Each cell corresponds to an interlinkage: the SDG labelling the column influences the SDG labelling the row. White space indicates that the interlinkage is close to zero; colour bars to the right give the scaled strength of interlinkages in each case.

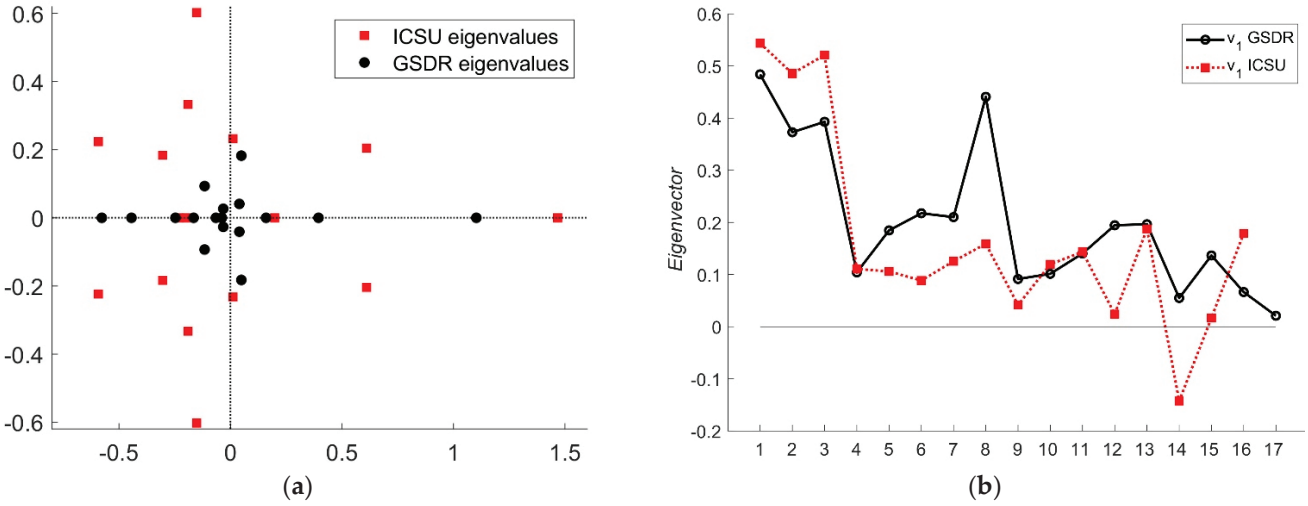

Figure 2. Eigenvalues and eigenvectors for the ICSU and GSDR interlinkage matrices. (**a**) Eigenvalues of the adjacency matrices A in the two cases. The leading eigenvalues are located at approximately $\lambda_1 = 1.47$ for the ICSU matrix and $\lambda_1 = 1.10$ for the GSDR matrix (both given to two decimal places). In both cases, there are significant gaps between this leading eigenvalue and the next-largest. (**b**) The leading eigenvectors v_1 for the ICSU and GSDR adjacency matrices, with the components for each SDG plotted against the SDG number on the horizontal axis. The vertical scale is somewhat arbitrary since eigenvectors are defined only up to a scale factor. Here, as is customary and convenient, they are normalised so that the sums of the squares of the components add up to one.

The asymmetry noticed above is reflected in the high values of the eigenvector components for SDGs 1–3; these three SDGs are positively supported by many of the others, which would lead to greater progress on those goals, in the dynamical sense, and for them to be identified as among the most important in a centrality sense. The GSDR matrix has a particularly high component also for SDG 8 (decent work and economic growth), which is expected due to the relatively full row of interactions supporting SDG 8 in the interaction

matrix in Figure 1b. The corresponding row for the ICSU matrix in Figure 1a also strongly supports SDG 8; however, in this case, the support is stronger for other SDGs and so SDG 8 does not emerge relatively better off.

Most concerning is the negative component of the leading eigenvector for SDG 14 (life below water) for the ICSU matrix. This suggests that the internal dynamics of the ICSU network would result in negative progress on SDG 14 when progress is made elsewhere. In terms of the interlinkage matrix, there are two strongly negative links, from SDG 2, and from SDG 11 to SDG 14; these are coloured dark blue in Figure 1a and point to significant trade-offs between the goals on zero hunger, sustainable cities, and progress on life below water.

Finally, Figure 3 shows the results of minimising the trophic confusion measure F defined in Equation (3) for the two networks. In both parts of the figure, the relative levels of the SDGs are determined so that as many of the directed edges point upwards as possible. Hence, the influence between the SDGs generally runs from the bottom of each figure to the top. It can be seen that SDGs 1–3 consistently appear close to the top of the figures and SDG 12 appears low down. SDG 17 does not appear in Figure 3a since it was not included in the ICSU analysis. The relative horizontal positions of different SDGs have no meaning in terms of interlinkages; they are purely to make the figures as easy to interpret as possible. One surprise in Figure 3b is the relatively high position of SDG 5 (gender equality). This illustrates that the construction of these hierarchies depends on the robustness of the underlying data; as noted above, SDG 5 is rather sparsely represented in the literature review that the GSDR matrix was built from. One useful direction for future research would clearly be to develop measures of the robustness or sensitivity of these hierarchy calculations to missing or biased data.

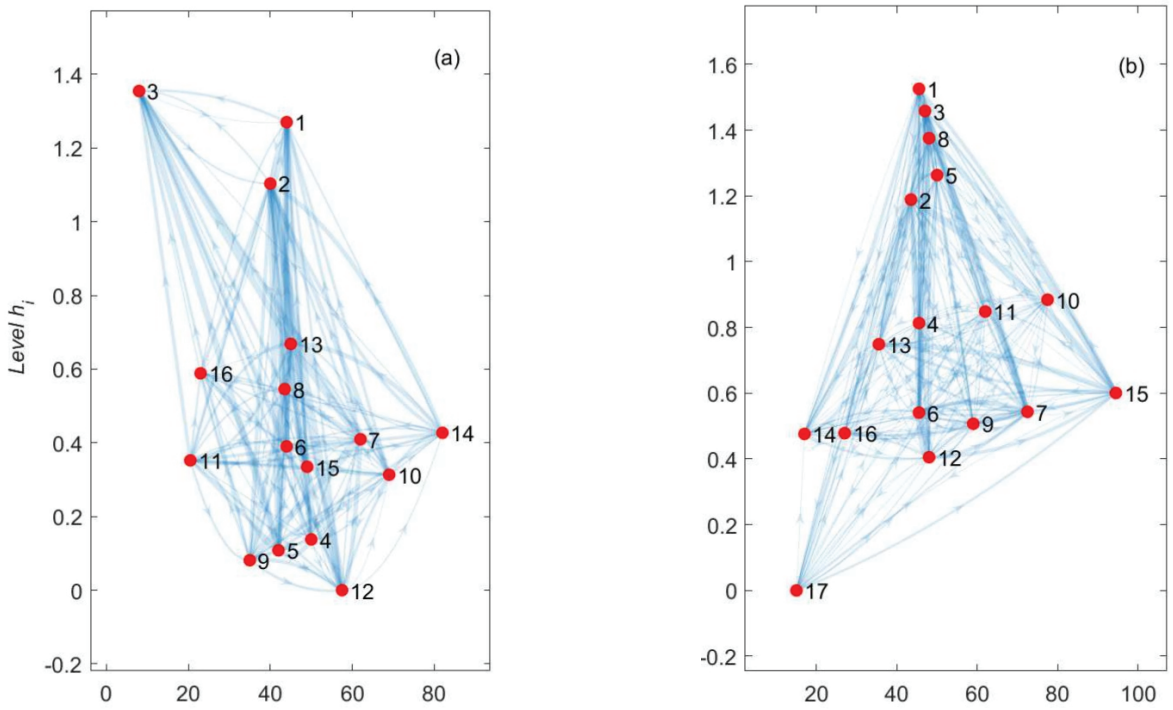

Figure 3. Hierarchies of nodes in the two networks. The vertical axes indicate the (relative) levels h_i, constructed so as to minimise the function F defined in Equation (3), and placing the node at the lowest level at zero. The horizontal positions of nodes are chosen just so that as many links as possible in the network are straight lines. (**a**) Hierarchy of nodes in the ICSU matrix: SDG 12 (sustainable consumption and production) has most influence on other SDGs, whereas SDGs 1–3 are the most influenced by others; (**b**) hierarchy of nodes in the GSDR matrix: SDG 17 (partnerships for the goals) is the most influencing, and SDGs 1, 3, and 8 are the most heavily influenced by the others.

5. Conclusions

The aim of this article is to introduce fundamental concepts in network science and show that they are able to contribute to the understanding of the study of SDG interlinkages, and in particular to the challenge of drawing system-level inferences from a set of individual pairwise interactions between the 17 SDGs, or indeed at the level of the 169 individual targets. After brief discussions of centrality in Section 1 and hierarchy in Section 2, two example networks were presented in order to illustrate the mathematical tools. The results illustrate the kind of overall conclusion that could be drawn about the structure of the interlinkage networks that was less obvious and certainly less quantifiable without the mathematical analysis available. The central conclusion is that progress on SDGs 1, 2, and 3 appears to be much more likely than progress on others, and that notably SDGs 14 and 15 are less well reinforced by the remainder of the goals, perhaps pointing to the need for additional policy interventions.

Of the many directions for future research, I touch on a couple of the most obvious and pressing. First, the degree to which the results are sensitive to biases, missing input data, and the details of the construction of any interlinkage network is obviously extremely important if the results are to have any validity. In part, detailed knowledge of the limitations, or indeed the rationale behind any one interlinkage network should be known and understood at the time of construction or data collection. The results for that network must then be interpreted in that light; without that context and background understanding, interpretation of the results is likely always to be misleading. In the context of the SDGs, the data gaps are well known but significant [13]. This report highlights both the gaps in coverage, noting for example that, for five of the SDGs, fewer than half of the 193 countries or areas have internationally comparable data, and also, more subtly, that the most recent data available in many cases is 5 or 6 years old. This lack of timeliness of data is noted as being particularly a concern for SDGs 1, 4, 5, and 13.

Given that the analysis of interlinkages through historic data depends on data being available for pairs of SDGs, so that their mutual dependency can be explored, the case for the involvement of expert analysis in the identification of interlinkages is perhaps made stronger, despite its more qualitative appearance and well-understood inherent subjectivity.

Recent work has explored mathematical measures of the sensitivity of the leading eigenvector and eigenvalue to perturbations in the network [14], and it is likely that similar approaches can be used to understand the robustness of the hierarchy calculations as well. The hierarchy calculations can also be formulated in many different ways, for example, making different choices for the target spacings g_{ij} in Equation (3). There are indeed a number of different 'natural' choices for g_{ij}, and, more generally g_{ij} allows the formulation of some kind of 'prior structure' that one might wish to impose on the answer, for example, pairs of SDGs whose levels should be more or less closely aligned than other pairs of SDGs due to some structural influence or geographical restriction. These issues deserve to be the subject of future investigations.

Other centrality measures, building on eigencentrality, might also be useful in order to explore more fully the connected nature of the network. There is related literature that allows the inclusion of three-way interactions between nodes in a directed network [15] (and references therein); this may be another helpful direction for these SDG networks in particular.

To conclude, while the construction of interlinkage networks is in itself a demanding and complex task, it appears to be gaining momentum as a way to visualise structure within the set of SDGs; it follows that appropriate network tools should be used to extract the system-level metrics and conclusions that follow from the interlinkage network. This second step, while of course inheriting biases present in the network data, is crucial in understanding in policy terms the emergent features that the interlinkage network represents and how best they should be addressed.

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Proceeding Paper

Impact of Water Supply Quality for Residents in Rio de Janeiro State, Brazil, during the COVID-19 Pandemic †

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Abstract: In Brazil, especially in the State of Rio de Janeiro, an environmental, health and humanitarian crisis is becoming evident due to the water supply crisis in the region. Therefore, the aim of this study was to evaluate the perception of consumers regarding the quality of water in the State of Rio de Janeiro, during the COVID -19 pandemic. A survey was conducted with 289 participants, who were residents of the State of Rio de Janeiro, after approval by the Research Ethics Committee of Federal University of the State of Rio de Janeiro (UNIRIO), from 26–30 of April 2021. Of the respondents, 40.83% reported that the drinking water is of low quality.

Keywords: water; Rio de Janeiro; Brazil

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1. Introduction

Access to safe and clean water is a right for everyone and essential for human health and life. As advocated by the United Nations, it is Sustainable Development Goal number 6 to ensure the availability and sustainable management of safe drinking water and sanitation for every individual [1]. The availability of water and its sustainable management are also related to the maintenance of basic human necessities and the guarantee of Food and Nutritional Security, which is affected by food safety and the lack of adequate water, sanitation, and hygiene facilities [2].

In Brazil, since 1977, the Ministry of Health has been responsible for the potability standard of water for human consumption, as well as defining the responsibilities and technical competencies of each organization of the Unified Health System (SUS) in the National Program for Water Quality Surveillance, known as Vigiagua [3]. It is essential to ensure that the supplied water meets the quality requirements for the uses for which it is intended. However, the Brazilian State of Rio de Janeiro faced two water supply crises during the pandemic of COVID-19, due to the presence of geosmin [4].

Geosmin and 2-methylisoborneol are organic compounds that can be synthesized by cyanobacteria, causing taste and odor in tap water. Many species of filamentous cyanobacteria, such as Anabaena, Planktithrix, Pseudanabaena (Planktonic), Phormidium, Oscillatoa and Lyngbya, have been confirmed as producers of geosmin and 2-MIB [5–8].

The presence of geosmin occurs due to the eutrophication of water springs, which contributes to the blooming of algae and cyanobacteria. In favorable environmental conditions, cyanobacteria show an accelerated growth, causing the phenomenon known as "bloom", with the appearance of stains on the water surface. Associated with this phenomenon is the production of compounds that confer taste and odor to water, such as MIB (1,2,7,7-tetramethylbicyclo-[2.2.1] heptan-2-ol, or simply 2-methylisoborneol) and geosmin (Trans-1,10-Dimethyl-trans-9-decalol) [6].

This "bloom", which promotes the increase of geosmin, due to the organic matter, is a result of the environmental pollution present in the river that supplies the city, by the untreated sewage load from the upstream cities. The Water Treatment Plant (WTP) of Guandu, located in Rio de Janeiro, belongs to the company responsible for supplying 16 cities and a population of 9 million inhabitants that are dependent on the Guandu System [6]. The main source of water supply in the metropolitan region of Rio de Janeiro, the Guandu River, passes through 15 towns until it flows into the Guanabara Bay, and it is the only source of water for subsistence and development in that region [3,9,10].

Many processes have been studied for the removal of these compounds; however, these approaches are costly and environmentally unsustainable for continuous use [11]. However, the Brazilian legislation does not determine the maximum permitted values for geosmin and 2-MIB in drinking water, as they are not associated with health problems, but there are standard limits described for taste and odor.

In April 2021, amid another crisis caused by geosmin, the water supply company (CEDAE) was divided for the concession of water and sewage distribution in four blocks of cities of Rio de Janeiro, including the capital, for 35 years.

It was privatized with the justification of ensuring the basic right to sanitation, since there is not even sanitation in many Brazilian cities. The sewage is in the open, causing various health problems, mainly due to poor quality water for residents, although the municipal plan of basic sanitation in the municipalities is required by law to ensure this right to the population. In addition, this concession may promote an increase in unemployment and tariffs related to the supply of water in the State of Rio de Janeiro [12].

The CEDAE auction raised R$22.6 billion with the sale of three of the four blocks offered [12] with the exception of Block 3, which includes the western zone of Rio de Janeiro and six other cities (Piraí, Rio Claro, Itaguaí, Paracambi, Seropédica and Pinheiral), an area of high concentration of peripheral neighborhoods. In addition, another problem in the west zone is the dumping of raw sewage that, after decades of neglect, is killing Sepetiba Bay, around which almost two million people live [13].

Therefore, in addition to the health crisis due to the COVID-19 pandemic, the State of Rio de Janeiro evidences the environmental and humanitarian crisis due to the water supply crisis. Thus, the aim of this study was to evaluate the perception of consumers regarding the quality of water in the State of Rio de Janeiro, during the COVID-19 pandemic.

2. Materials and Methods

An online survey was conducted, after approval by the Research Ethics Committee of the Federal University of the State of Rio de Janeiro (UNIRIO), No. 30994920.6.0000.5285, and the permission of the participants by signing the electronic Informed Consent Form (ICF), respecting the ethical aspects of the research.

The study took place from 26 to 30 April 2021, when the State of Rio de Janeiro counted 43,965 deaths due to the COVID-19 pandemic. People of both genders, aged 18 years or older, who were residents of the State of Rio de Janeiro, were invited to answer the survey. A total of 289 individuals participated in the survey. The Human Development Index (HDI) in Rio de Janeiro was 0.761 in the year 2019 [14]. However, it is important to stress that social inequality is high in the State of Rio de Janeiro, as well as throughout Brazil.

The survey was elaborated with closed questions on aspects related to access to drinking water and its quality, social isolation due to the new coronavirus pandemic, and socioeconomic data. The data were collected through the Google Forms platform, tabulated in the Excel® program, and analyzed by the software Epi Info 2002, through the Chi-Square test and $p < 0.05$ for statistical significance.

3. Results

Table 1 presents the results of the characterization of the research participants and classification regarding the social isolation practiced by individuals residing in the State of Rio de Janeiro.

Table 1. Characterization of individuals residing in the State of Rio de Janeiro and evaluation of drinking water consumption and economic aspects during the pandemic.

Question	Answer	N	%
Gender	Female	225	77.85
	Male	62	21.45
	Undeclared	2	0.69
Region	Baixada Fluminense	33	11.42
	Rio de Janeiro	256	88.58
Education	Primary School I	01	0.35
	Primary School II	03	1.04
	Secondary School	120	41.52
	Higher Education	59	20.42
	Specialization	43	14.88
	Master's Degree	42	14.53
	Doctorate	21	7.27
Family income	≥U$192.00	279	96.54
	<U$192.00	11	3.46
Age	18 to 29	149	51.56
	30 to 39	61	21.11
	40 to 49	31	11.07
	50 to 65	41	14.19
	≥66	6	2.08
Classification of social isolation measures adopted	Leaving home only when it is inevitable	128	44.29
	Being careful, but still leaving home	146	50.52
	Complete isolation	6	2.08
	Living normally, without changing the routine	7	2.42
Water quality	Indifferent	56	19.38
	Good	116	40.14
	Bad	117	40.48
Source of drinking water	Water treatment plant	166	19.37
	Mineral water	84	29.07
	Both	189	13.49
Treatment of the drinking water	Without treatment	08	2.77
	Filtered	158	54.67
	Simmered	04	1.38
	Mineral water	78	26.99
	Mineral and Filtered water	41	14.19
Spends on water	Yes	239	82.70
	No	50	17.30
Water costs have increased	Yes	233	80.62
	No	2	0.69
	Not applicable	54	18.69
During the pandemic there was a change in individual/family income	Yes, the income has decreased	130	44.98
	Yes, the income has increased	24	8.30
	No, the income remained the same	135	46.71
The drinking water and sanitation are considered a sustainability strategy	Yes	256	88.58
	No	33	11.42
Total		289	100

Most of the interviewees were female (77.85%), aged between 18 and 72 years old; 88.58% lived in the city of Rio de Janeiro and 11.42% in Baixada Fluminense, which comprises the most peripheral cities. Of those interviewed, 20.42% had completed higher education, 14.88% had a specialization and 21.80% had a master's or doctoral degree. As for income, 96.54% earned at least 192 dollars per month. Regarding isolation, 51.56% were

being careful but leaving home during the pandemic period, and 44.64% were leaving home only when necessary (Table 1).

Regarding the quality of the water, 40.83% evaluated the water as having no quality, 19.38% as regular and 39.69% as good for consumption. Furthermore, 42% used bottled mineral water, 36.33% used tap filter, 6.57% clay filter and 30.80% electric filter (Table 1).

Of the respondents, 80.28% reported having water expenses, and during the pandemic, for 80.62% there was an increase in water expenses. Regarding income, 44.98% reported a decrease of the income during the COVID-19 pandemic, and 88.58% of the respondents considered safe water and sanitation as a sustainability strategy (Table 1).

Table 2 shows the association between the variables studied, with an association between gender and perception of water quality, which was more evident for females (p = 0.008). The quality of water supply directly influences the treatment of water by consumers, and it is evident that individuals who had high perception of low-quality water sought mineral water for daily consumption (p = 0.000). Consumers who perceived poor water quality are those who classify water and sanitation as sustainability strategies (p = 0.001). However, no association was found between the pandemic and the increase of water expenses (p = 0.048), showing that the water crisis in Rio de Janeiro is chronic.

Table 2. Association of water quality with gender, region, age, family income, change in income during the pandemic, source of drinking water, treatment of drinking water, change in water expenses during the pandemic and drinking water and sanitation are considered a strategic sustainability issue.

		Quality of the Drinking Water						Value of p
		Indifferent		Good		Bad		
		n	%	n	%	n	%	
Gender	Female	44	15.22	79	27.34	102	35.29	0.008
	Male	12	4.15	35	12.11	15	5.19	
	Undeclared	0	0.00	2	0.69	0	0.00	
Region	Baixada Fluminense	8	2.77	11	3.81	14	4.84	0.631
	Rio de Janeiro	48	16.61	105	36.33	103	35.64	
Family income	≥U$192.00	2	0.69	4	1.38	4	1.38	0.999
	<U$192.00	53	18.34	112	38.75	114	39.45	
Age	18 to 29	30	10.38	57	19.72	62	21.45	0.051
	30 to 39	6	2.08	33	11.42	22	7.61	
	40 to 49	5	1.73	14	4.84	13	4.50	
	50 to 65	12	4.15	10	3.46	19	6.57	
	>66	3	1.04	2	0.69	1	0.35	
Spends on water	Yes	45	15.57	79	27.34	108	37.37	0.449
	No	11	3.81	37	12.80	9	3.11	
Source of drinking water	Water treatment plant	26	9.00	70	24.22	70	24.22	0.164
	Mineral water	24	8.30	29	10.03	31	10.73	
	Both	6	2.08	17	5.88	16	5.54	
Treatment of the drinking water	Without treatment	1	0.35	6	2.08	1	0.35	0.000
	Filtered	28	9.69	89	30.80	41	14.19	
	Simmered	1	0.35	1	0.35	2	0.69	
	Mineral water	21	7.27	9	3.11	48	16.61	
	Mineral and Filtered water	5	1.73	11	3.81	25	8.65	
Water costs have increased	Yes	7	2.42	7	2.42	9	3.11	0.481
	No	21	7.27	57	19.72	51	17.65	
	Not applicable	28	9.69	52	17.99	57	19.72	
The drinking water and sanitation are considered a sustainability strategy	Yes	42	14.53	109	37.72	106	36.68	0.001
	No	14	4.84	7	2.42	11	3.81	

4. Discussion

COVID-19 is an infectious disease and is caused by a newly discovered coronavirus that has spread rapidly around the world [15]. Transmission happens from one sick person to another or through close contact [16,17]. Due to the means of interpersonal transmission and the rapidity with which it spreads, several regions of the entire world have been

quickly affected, configuring what is known as a "global pandemic", a major challenge for the world [16,17].

In Brazil, the challenges are even greater due to the particularities found in the country, resulting from high social inequality, where the population finds itself without systematic access to water and in situations of low-income urban agglomerations, referred to as subnormal agglomerations (subnormal agglomerations are forms of irregular occupation of land owned by others—public or private—for housing purposes in urban areas and, in general, characterized by an irregular urbanistic pattern, lacking essential public services and located in areas with occupation restrictions [18]), known as "favelas" or communities, where many people live in precarious conditions, without access to health, social and financial support [19,20].

With the increase in the number of cases of infection and death from COVID-19, social distancing was seen as a non-pharmacalogical strategy [21,22], able to control the exponential growth of the disease, protecting health systems from collapse, due to demand far exceeding supply [19,23]. On the other hand, the distancing has strongly affected the lives of citizens, increasing social inequality, unemployment, hunger, and poverty [15,21].

In Brazil, transmission one year after the start of the pandemic is high, so distancing measures continue [15]. According to Bezerra et al. [24], this adherence may have something to do with the fear of becoming infected and suffering even greater health and financial losses.

In addition, the present study points out that 4% of the interviewees receive less than one minimum wage (US$ 192 dollars) per month, and more than 50% of the interviewees had decreased or maintained their income from before the pandemic. Therefore, the pandemic finds the Brazilian population in a situation of extreme vulnerability, with high rates of unemployment and deep cuts in social policies, in addition to the growing and intense throttling of investments in health and research in Brazil, triggered by the political crisis [19].

Along with all the crises experienced in Rio de Janeiro, Brazil, the hydric crisis has been evidenced [25]. It is known that water insecurity is measured by the irregular supply, or even the lack of drinking water, and reached, in 2020, 13.2% of households in the Southeast region of Brazil, where the State of Rio de Janeiro is located. The lowest rate of water insecurity is in the country, compared to the Northeast (40.2%) and North (38.4%) regions, but it is a reality that still exists in the region. It is also important to highlight the association between food insecurity and water insecurity. The proportion of households classified as suffering from serious food insecurity (hunger) doubles when there is no adequate availability of water for food production [26]. Among the conditions that increase the transmission of the SARS-CoV- 2 virus is greater home agglomeration, which occurs more frequently in households and in the poorer regions of the country.

On June 28th of 2021, the Minister of Mines and Energy at the time, Bento Albuquerque, made a statement on national television, affirming that the country is going through a water crisis and asked for a "conscious and responsible" use of water and energy by the population, since the last rainy season was the driest in 91 years [27]. This crisis directly impacts the lack of water for consumption, more expensive electricity bills and blackouts [26].

This water crisis is the result of a sum of factors related to water and sustainability, such as deforestation of the Amazon Forest; global warming caused by burning fossil fuels; and the natural phenomena La Niña [26,28–31]. On other occasions it was necessary to ration the water supply to minimize these impacts on the Brazilian population. In some regions of Brazil there was even a rotation of days with the water available in the cities, to save water.

The results of this study highlight the water crisis experienced by the State of Rio de Janeiro, resulting from the pollution of the Guandu River basin [25]. Of the interviewees, 40.83% reported that the drinking water coming from the water treatment plant has low

quality. Of those surveyed, 13.15% are from Baixada Fluminense and of those, 28.24% reported that the water that reaches their taps does not have good quality.

Water security deals directly with the pressures of global urban growth and its interference with water resources, which in turn affects sustainability and the protection of human health [31,32].

Problems with water supply are not recent. In 2015, the entire Southeast region of Brazil, including the State of Rio de Janeiro, experienced a water crisis; however, it is noteworthy that problems still experienced by the population nowadays are the lack of water or irregular supply (two or three times a week), particularly in less favored areas such as the Baixada Fluminense, showing the correlation between water and social crisis [33]. With the new sanitation decree, due to the approval of Law 14026/2020, which deals with the new Legal Framework for Basic Sanitation, water supply and sanitary sewerage services are under transformation in Brazil. The National Sanitation Plan and the new Sanitation Law set targets to bring the country closer to a universalization agenda for 2033. According to Law 14026/2020, the operating companies should serve 99% of the population with treated water and 90% with the collection and treatment of sewage [34].

Food systems are known to have an important role in promoting environmental sustainability, such as climate change adaptation and migrations, biological diversity and soil and water degradation [2]. Water stress in the water-abundant Latin American and Caribbean region has fueled several conflicts between various sectors, including agriculture, hydroelectricity, mining and even drinking water and sanitation. Water is universally underestimated and undervalued. Unfortunately, there are few governments, companies or citizens demanding that water should be valued.

5. Conclusions

Brazil is the fifth largest country in territorial size, with a population of over 210 million inhabitants. However, the current basic sanitation services are not provided to all Brazilians and a large part of the population has no access to sewage treatment. The National Basic Sanitation Plan established important goals and guidelines for the advancement of the levels of attendance of water and sewage services in Brazil. It is believed, however, that not enough has been invested in basic sanitation in the country, highlighting the need for reforms to increase investments and thus raise the coverage and quality of water and sewage services in Brazil.

It is suggested that these measures, combined with new technologies such as reused water, among others, can make potable water available for the entire Brazilian population, especially for the State of Rio de Janeiro, which again experienced one of the worst water crises. It is hoped that this research can be reproduced in other locations, considering the different realities and potentialities of each region.

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Proceeding Paper

The Impacts of the Pandemic on Sustainable Production and Consumption: Toward a System Dynamics Approach †

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Abstract: The pandemic in 2020 called for developing a recovery plan and action in designing a robust and sustainable supply chain worldwide. In developing the models in the context of sustainable development, a holistic approach is needed. Hence, the stakeholders' value chain, the impacts of policies, and short/medium- and long-term planning horizon should be integrated into developing and analyzing the models. This work in progress research proposes a system dynamic approach for addressing the impacts of the pandemic on goal 12. First, the subsystems and causal loop diagram of the main elements of sustainable production and consumption are provided. Then, the scenarios and the perspective of application are discussed.

Keywords: pandemic; sustainable goals; production and consumption; system dynamics

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1. Introduction

Sustainable development goals are the common agenda for nations to save our planet. The UN SDG outline includes 17 goals with several targets for the operationalization of sustainable development by 2030. The COVID-19 pandemic influenced the global economy, business, socio-economic systems, and human behaviors with different short- and long-term impacts on the people, planet, and profit. One of the essential goals in the UN agenda is goal 12 that seeks sustainable production and consumption. This goal includes different stakeholders and covers the life cycle approach of several sectors including mobility, food, agriculture, housing, and appliances. By June 2021, the pandemic, with more than 177 million cases and 3.8 million deaths, influenced the realization of SDG goals. The main elements in goal 12, including reducing material consumption and footprint, increasing the recycling rate, decreasing food waste, management of hazardous substances, and increasing the number of policies for promoting sustainable production and consumption. The impacts of the pandemic on these targets should be analyzed by considering certain scenarios. Several studies recently focused on the impacts of COVID-19 on supply chain and logistics [1–4]. A few studies also studied the impacts on some of the SDG goals. However, to the best of our knowledge, addressing the impacts of the pandemic on goal 12 in a systematic way and via a simulation model was not a prime focus of prior research. The system dynamics approach provides the opportunity to assess a large-scale problem with several influential factors [5]. This study aims to discuss the application of system dynamics in evaluating the impacts of COVID-19 on goal 12. The rest of the paper is organized as follows: Section 2 discusses the literature review. Sections 3 and 4 provides the methodology, the model, the scenarios, and the application perspective. Finally, Section 5 provides a summary and future research.

2. Literature Review

In this section, a brief review on goal 12, the research on sustainable production and consumption, the studies on the impacts of COVID-19 on SDG goals, and the system dynamics approach are provided.

2.1. Goal 12 and the Current Situation

In 2015, the 2030 agenda for sustainable development is agreed upon by all the United Nations members. This agenda with 17 goals provides the shared values for protecting our planet and aids in peace and wealth for all people [6]. One of these goals is ensuring sustainable production and consumption pattern (goal 12) with 11 targets. The indicators based on the UNEP source are provided in Figure 1 [7]. These indicators aid in measuring the achievement of the determined targets to help nations' performance evaluation in the sustainability of production and consumption and highlight the deviations for taking appropriate actions. These indicators include the policies for sustainable procurement, the material footprint, the food wastes, the recycling rate, the hazardous substances, publishing corporate social responsibility reports by companies, and material consumption. The pandemic in 2020 influenced the achievement of these targets. According to the UN report, in 2010, the global material footprint was 73.2 billion metric tonnes that are increased by 17.3% in 2017. From 2017 to 2019, for 79 counties and the EU, at least one policy related to goal 12 is reported. By 2019, only 20% of electronic wastes are recycled, and these wastes are grown by 38%. Despite the target of reducing the fuel subsidies, they were increased by 34% from 2015 to 2018. The food wastes through the supply chain stream were reported at around 13.8% in 2016 [8].

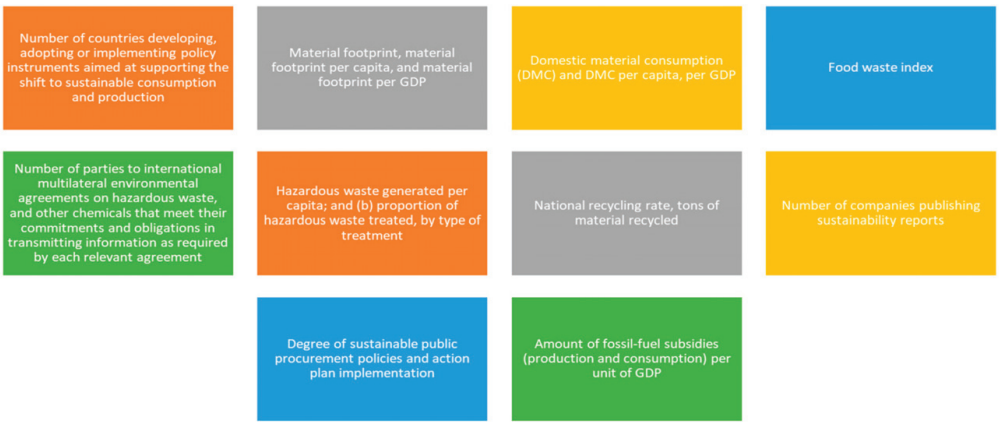

Figure 1. The indicators for goal 12 (source of data: UNEP [7]).

2.2. SDG Goals and Impacts of the Pandemic

Pradhan et al., performed a systematic review on the interactions between SDG goals. They considered the positive correlation as synergy and the negative as a trade-off. On the basis of the indicators and the data of 227 countries, they concluded that goal 1 (no poverty) has the most synergetic relations with the other SDG goals, and goal 12 is most linked to the trade-offs. Hence, for trade-offs, indicators and targets should be well discussed and negotiated for achieving better outcomes of these strategies [9]. Sala and Castellani used a life cycle assessment approach for evaluating the environmental impacts of food, mobility, housing, household goods, and appliances. They concluded that food is the most important area of consideration. The use phase plays an essential role in mobility, appliances, and consumption housing. For food and household goods, the upstream of the supply chain plays an essential role in environmental impacts [10]. Gasper et al., discussed goal 12, related targets, indicators, and policies. They mentioned that several challenges are existed related to the indicators and monitoring the target across the countries. They suggested developing the national targets for improving the outcomes [11]. Chan et al., reviewed goal 12 and they highlighted several gaps including focusing on the material footprint with reducing the overall consumption, improving the knowledge of decision-makers, policymakers, consumers, and businesses on sustainable production and consumption [12].

A few studies recently considered the impacts of the pandemic on goal 12. Elavarasan et al., studied the impacts of the pandemic on goal 7 (energy sustainability). They used

AHP and SWOT analysis to address the post-pandemic scenarios. They also discussed the impacts of COVID-19 on all 17 SDG goals and the challenges and solutions of the energy sector. For goal 12, they mentioned the availability of resources in healthcare systems and hospitals and the generated medical wastes during the pandemic as an important challenge. They suggested the optimization of consumption and production, promoting the 3R approach (reducing, reusing, recycling) and using the sharing platforms as the solutions for dealing with challenges [13]. Nundy et al., studied the impacts of the pandemic on energy, transport, and socio-economic sectors. They mentioned decreasing the energy demand in the transport sector and revenue loss while increasing energy consumption in the residential sector. The pandemic influenced SDG targets achievement by 2030, and a collaborative mitigation plan is required [14]. Health also considered the impacts of the pandemic on SDG goals. The author discussed that achieving goals 7–9 and 11–15 with the long-term impacts of COVID-19 is challenging. The economic recession affects the policies and the implementation of SDG goals [15]. Several studies addressed the impacts of the pandemic on supply chain and logistics [1–4]. Kumar et al., discussed the impacts of the pandemic on sustainable production and consumption. They recommended the policies in this area. For production, the policies should be revised to consider the impacts of COVID-19 with appropriate incentives. Industry 4.0 and digital manufacturing should be developed. The coordination between different stakeholders should be performed. The real-time monitoring and control of production could reduce the impacts of disruption. For consumption, e-commerce is growing considerably during the lockdowns. The role of social media is essential in evaluating consumers' behavior. The uncertainties of the consumers' demand should be managed with the resilience of the supply chain and certain strategies for risk management [16].

2.3. System Dynamics Approach in the Sustainable Development Context

System dynamics is a powerful approach for assessing the complexity and the interaction of the dynamics models. This approach is used in the context of sustainable development considering the complexity, the role of different stakeholders, and the variation in the influential variables. Hjorth et al., used system dynamics in the context of sustainable development. They mentioned complexity and the self-organizing system as the characteristics for using this approach [17]. Giannis et al., used system dynamics for evaluating different recycling scenarios. They applied this approach due to several influential factors on waste management including population, rapid economic growth, and consumer patterns [5].

The synthesis of the literature highlight the following points:

- Goal 12 of SDG plays an essential role in sustainability and more research is required considering the trade-offs, the complexity, and the challenges of the current indicators.
- The pandemic affects the realization of SDG goals by 2030. A few studies discussed the impacts on the goals. However, focusing on goal 12 and the related indicators has not received much attention in the literature.
- System dynamics is an effective approach for addressing the complexity and self-organizing nature of sustainable development problems. This approach could aid in analyzing the impacts of COVID-19 on the key elements of goal 12.

3. Research Approach

In this section, first, the essential indicators of goal 12 related to production and consumption are addressed. For this study, we focused on domestic material consumption, material footprint, food wastes, and recycling rate. The software Vensim PLE was used for designing a system dynamic model. Figure 2 shows the causal loop diagram. The increasing number of COVID-19 patients caused several shutdowns of manufacturing units and led to supply chain disruption, reduction in logistics operation, and transport. The resulted disruption decreased the allocated resources of the enterprises on sustainable procurement and publishing the corporate social responsibilities (CSR) reports. The priorities for the

countries are shifted as the results of the loads on healthcare systems and hospitals. Hence, it decreases the number of developed and adopted policies in sustainable production and consumption. The disruption in the logistics and supply chain also caused a decrease in the material footprint and hazardous wastes generated from factories. The lockdowns of restaurants and the cities contributed to decreasing food wastes. However, the impacts on the wastes through the supply chain require detailed data. The huge consumption of medical protection items such as glasses, face shields, surgical masks, and gloves generated a considerable amount of solid waste. The recycling, landfilling, and proper treatment of these wastes should be addressed in the related policies. The main dynamic equations in this study are presented in this section. Equations (1)–(5) show the system equations based on UNEP metadata of the goal's 12 indicators [7]. Three elements are essential in domestic material consumption: direct import material, domestic extraction, and direct exports. For material footprint, the raw material of import, domestic extraction, and raw material of exports should be considered. Food wastes are the result of two indexes: food waste proportion to total wastes and the food wastes during different supply chain tiers. The other indicator is recycling rate, which is a function of material recycled, material exported and imported for recycling, and total wastes. Figure 3 shows the system dynamic model including five subsystems.

$$\mathrm{DMC} = M_{Im} + M_{Ext} - M_{exp} \tag{1}$$

$$MF = RM_{Im} + M_{Ext} - RM_{ex} \tag{2}$$

$$Food_{wastes} = \left\{ \frac{Fw}{T\_W}, \sum_{i=1}^{n} Fw_{tier_i} \right\} \tag{3}$$

$$R_{rate} = \frac{(M_{recy} + M_{exp\text{-}recy} - M_{Imp\text{-}recy})}{T\_W} \times 100 \tag{4}$$

$$T_W = W_{man} + W_{Econ} + W_{e,g,s,a\text{-}supply} + W_{mun} \tag{5}$$

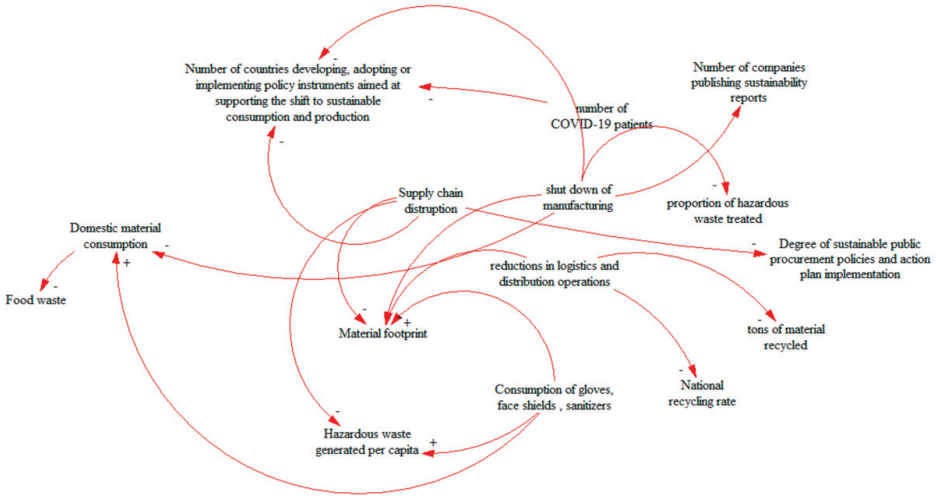

Figure 2. Causal loop diagram model for the impacts of the pandemic on goal 12 indicators.

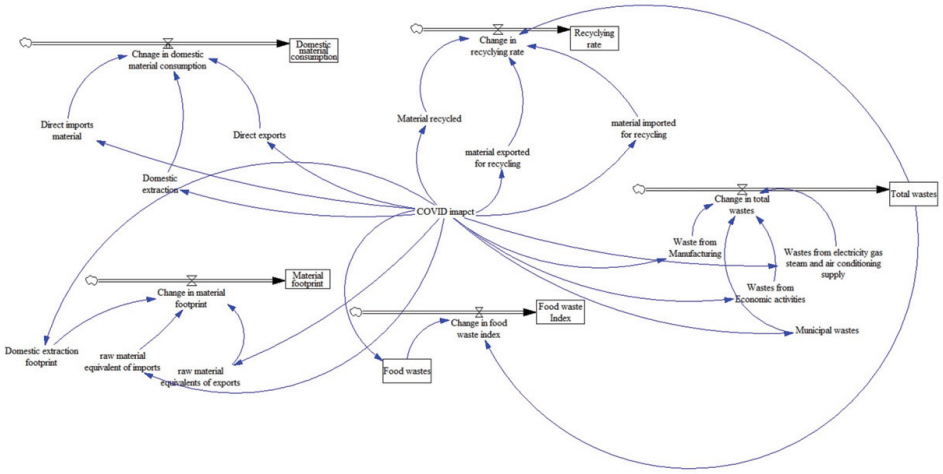

Figure 3. The system dynamic model with five sub-systems.

The first sub-system is domestic material consumption. The second is the material footprint. The national recycling rate, total wastes, and the food wastes index are the third, fourth, and fifth sub-systems in the proposed model, respectively. A scenario generation process based on the COVID-19 data could be designed to address the different states. For example, Ivanov used three scenarios for addressing the impacts of COVID-19 on the supply chain disruption (S1: outbreak in China, S2: outbreak in China, US and Europe, and S3: epidemic crisis) [1]. The severity and the duration could be added for building different scenarios. Table 1 shows the examples of the scenarios based on three factors of the region: outbreak, severity, and duration.

Table 1. The examples of the generated scenarios.

Scenarios	Regions' Outbreak	Severity	Duration
1	Asia	High	3 months
2	Asia + US and Europe	High	6 months
3	Asia	Moderate	3 months
4	Asia + US and Europe	Moderate	3 months

4. Application Perspective

One of the main challenges in performance evaluation based on SDG goals is the availability of data. Tracking and tracing these data is challenging due to the complexity of the supply chain and the interaction among the sectors. For example, measuring the wastes in different food supply chain tiers is challenging. Hence, for facilitating accessing data, the country data are proposed for testing and validating the model. The uncertainties in data are related to the randomness of a factor and the lack of knowledge [8,18]. In this context, using the fuzzy number is promising for the design of the experiment. Hence, using the data of Canada and applying fuzzy numbers for some of the variables is the authors' agenda for the completion of this work in progress research.

5. Conclusions

The operationalization of sustainable development in supply chain and logistics is the key issue in the realization of the United Nations (UN) goals. Goal 12 addresses responsible production and consumption. It includes the sustainable use of natural resources, waste management, applying sustainability through 3R (Reduce, Reuse, and Recycle), and management of the product's life cycle. According to the recent report of the UN, we still face challenges in achieving sustainable production and consumption. The consumption of natural resources is not sustainable. The recycling rate of the consumed products, particularly the electronic products, is far from the target rate. The wastes in the food supply chain

during harvesting, transportation, processing, and storage are considerable. Reduction in oil prices and fossil fuel subsidies lead to more emissions and climate change. Technology revolution could play an essential role as leverage in achieving sustainable development goals. The UN's sustainable development goals are interconnected. Moreover, sustainable production and consumption and industry 4.0 play an essential role in future city planning. Smart sustainable cities are an emerging research theme that addresses the main concerns in planning, transportation, energy consumption, and the risks related to climate change in the new digitalization era. The pandemic in 2020 changed the global production and consumption patterns and affected the strategies and policies in achieving the SDG goals. The system dynamics approach provides a simulation environment for analyzing the different scenarios. The multiple feedback relationship between material consumption, material footprint, recycling rate, total wastes, and the food wastes index sub-systems are designed to permit analyzing different scenarios and the impacts on goal 12. This visualization tool aids decision-makers and policy planners in developing effective strategies and new indicators in the context of SDG. In this study, we focused on five essential subsystems on the basis of the goal 12 indicators. However, considering the subsystem related to the number of countries adopting and implementing policies related to sustainable production and consumption, hazardous waste management, publishing CSR reports, and fossil fuel subsidies are also proposed as future research.

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Abbreviations

DMC	Domestic material consumption
M_{Im}	Direct imports material
M_{Ext}	Domestic extraction
M_{exp}	Direct exports
MF	Material footprint
RM_{Im}	Raw material equivalent of imports
RM_{ex}	Raw material equivalents of exports
$Food_{wastes}$	Food wastes in the waste stream and in the supply chain
Fw	Food wastes
T_W	Total wastes
Fw_{tier_i}	Food wastes generated in tier i of the supply chain
R_{rate}	Recycling rate
M_{recy}	Material recycled
$M_{exp\text{-}recy}$	Material exported for recycling
$M_{Imp\text{-}recy}$	Material imported for recycling
W_{man}	Waste from Manufacturing
W_{Econ}	Waste from other economic activities
$W_{e,g,s,a\text{-}supply}$	Waste from electricity, gas, steam, and air conditioning supply
W_{mun}	Municipal Wastes

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environmental sciences proceedings

MDPI

Proceeding Paper

Advancing Community Resilience through Community Radio: The Case of EK-FM in Western Kenya †

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Abstract: Community radio can serve as a crucial channel to disseminate information in rural locations. This is the case of the Ekialo Kiona Community Youth Radio (EK-FM) on Mfangano Island, Kenya. EK-FM has been a platform for communicating health information during the outbreak of COVID-19. Now, over one year into the pandemic, our MDP student team alongside EK-FM staff are assessing community needs and EK-FM's opportunities and limitations in meeting them. Motivated by the current negative impacts of COVID-19 on less privileged communities, we are developing organizational, financial, social, and strategic routes to enhance the radio's ability to uphold its community resilience goals. By engaging Mfangano's communities to understand the context surrounding EK-FM, we facilitate the discovery of community aspirations for the radio to connect Mfangano residents regardless of their location, whether about local Suba culture, health, or ecological issues. We also explore possible social entrepreneurial pathways and partnerships toward EK-FM's lasting financial viability.

Keywords: community radio; community inquiry; strategic planning; community-based organizations; financial assessment; COVID-19-adapted inquiry; virtual projects

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1. Introduction

When unexpected disasters beset a community, the right communication channel and voices are critical. Community radio (CR) can serve as that channel to disseminate information during crises, support programs, and motivate action in rural locations, especially where transportation and face-to-face interactions are challenging. Through broadcasts in local languages, community radio can help to build community resilience and foster development by publicly exploring the complex intersections of solidarity, cultural identity, and community health without relying on transportation to connect people physically. CR can further socioeconomic inclusion by providing communication channels when modern technologies or transportation are not feasible, or language and literacy are barriers. CR also advances inclusion with programming determined and delivered by the community. However, due to its size and vulnerability to economic pressures, CR can face financial obstacles. Consequently, the challenges of financial sustainability, community governance, and audience appeal must be addressed.

This is the case of the Ekialo Kiona Suba Youth Radio (EKFM), a youth-led FM radio station operated out of the Ekialo Kiona Centre (EK) on Mfangano Island in Lake Victoria, Kenya. EK-FM radio acted as a platform for communicating health information and

updates during the outbreak of COVID-19, partly substituting for travel to disseminate information among remote islands in the Lake Victoria area. COVID-19 has exacerbated the challenges that Mfangano Island's 26,000 residents face, but prior to COVID-19, these communities had already faced substantial social, economic, environmental, and health challenges, including a high HIV prevalence [1]. Although the remote location contributes to these challenges, they are a legacy of the invasive Nile Perch fishing industry introduced by British officials during colonial rule, which led to local ecosystem devastation and a high demand among fishermen for sex work [2]. Due to these challenges and historical legacies, EK-FM supports goals of community resilience, solidarity, and cultural and language revitalization for the marginalized Abasuba people, through unique programming in Suba and other local languages [1]. The radio and EK use a 90 km wireless internet connection crossing from Kisumu, over Lake Victoria, to the peak of Mfangano Island, the longest in East Africa. EK-FM broadcasts through this internet connection to the first wind-and-solar-powered 500-watt FM transmitter in Africa, across an 80 km radius, reaching Mfangano Island communities and listeners on other islands throughout Lake Victoria and the Kenya mainland.

EK partnered with Organic Health Response (OHR), a community resilience organization with a focus on public health, as well as with the University of Minnesota (UMN). Via a collaboration between UMN and OHR, UMN Master of Development Practice (MDP) students work with OHR and EK-FM on summer practica evolving with current EK-FM needs. Most recently, UMN student teams focused on radio content and cultural revitalization, developing COVID-19 health and safety radio content in Summer 2020 and compiling community radio effective practices in Spring 2021. Now, EK is in the process of rebranding itself into a new Kenyan community-based organization (CBO) called Abakunta to adopt a more community-led and community-directed model, which includes transitioning its leadership and management from OHR. This process is in line with the previous student team's recommendations for the radio to tap into the advantages of community ownership of programming. Rebranding requires strategic planning and organizational support. Abakunta envisions growth in three areas, financial sustainability, community engagement, and partnership strengthening, but current staff and volunteer capacity has not allowed them to pursue growth to date. Thus, these areas are the most constructive for our team to support Abakunta. We are working on organizational restructuring centering Abakunta and EK-FM's viability, building EK-FM's long-term capacity to operate independently from OHR.

Our role throughout this project has been entirely virtual and therefore facilitative due to the remote nature of the work and to support the capacity of local staff and volunteers as EK transitions to its CBO status as Abakunta. In the Methods and Results Sections, we describe the research, processes, and findings for each of the three areas: community engagement, financial sustainability, and partnership strengthening. The project is ongoing, so results are preliminary and will be expanded in the future.

2. Methods

Across the three project areas, reflexivity is important considering the team is composed of students from the United States, Egypt, and Uganda attending a United States-based academic institution and the clients are Kenyan professionals at a CBO. We periodically reflect upon how our positionalities, identities, and experiences influence our work and our core competencies and weaknesses, in order to help us to understand and combat our biases.

2.1. Community Engagement

The goal was to conduct a pilot community inquiry suited to the current local context. Understanding and preparing for non-internet-based community inquiry in remote settings during COVID-19 required extensive research and finding relevance to EK-FM. We conducted a literature review using keywords including 'community engagement',

'East Africa', 'remote', 'virtual', 'community inquiry', and 'community feedback.' The research presented many community inquiry methods, including paper surveys, SMS and USSD, social media, online surveys, town hall meetings, focus groups, and one-on-one interviews [3–12]. We incorporated findings on the ethical and accessibility considerations that community inquiry methods may encounter. For example, focus groups must be structured with considerations to local social dynamics for both participants and interviewers so that participants are more comfortable expressing themselves [3,4]. There were also gender-based considerations with accessibility, such as conflicts with caretaking and domestic responsibilities [4,11]. These methods and ethical considerations were presented to the production manager at EK-FM, who decided paper surveys would be the most appropriate at present due to cost, access to technology, staff and volunteer time, COVID-19 safety, and accessibility for those with limited literacy. Although paper surveys present a barrier to participants with limited literacy, EK-FM advised they would be easiest for friends or relatives to transcribe on low-literacy participants' behalf.

Additional methods to support the paper survey were suggested to provide more timely feedback, increase accessibility for community members with low literacy, and provide another method to engage listeners of varying age demographics. These include social media polls and questions requesting written responses (Facebook and WhatsApp), recorded audio clips sent to EK-FM's email or social media, on-air call-in periods where community members can respond to specific feedback questions on air, and surveys administered on air with responses via Short Message Service (SMS). Because this survey is programmatic, meaning it is being conducted exclusively for the improvement of EK-FM and to understand community needs and data remains with the organization, academic methodologies are not required and data collection tools can be more flexible.

Discussion with the production manager and colleagues identified the most effective and appropriate technology for the context. We agreed on a mixed approach, centering paper surveys as the most effective method to reach the widest audience, with social media and the multiple on-air survey methods as important supplementary methods to engage listeners. The paper survey is important if EK-FM wishes to distinguish responses of the Abasuba community from those of other listeners in the interests of cultural revitalization. The paper survey is also important as it provides a reasonable level of anonymity to respondents and does not require that respondents incur technology expenses. SMS responses to an on-air survey would be anonymous and engage listeners, but require access to one cell phone per respondent. All methods are also chosen to reduce unnecessary risk of COVID-19 transmission, as paper, on-air, and online surveys present much lower risk than in-person meetings, and replace the need for people to travel to give feedback with the opportunity to give feedback remotely. Per survey best practices, questions were checked to ensure that all possible answers were offered in multiple choice questions, double-barreled questions were avoided, attempts were made to avoid "leading" questions, demographics questions were positioned at the end, and questions were grouped by topic [13]. We also wrote multiple phrasings of many questions and sought feedback from EK-FM representatives with the goal of producing appropriately worded questions that would yield sufficient useful information for EK-FM without reaching an excessive length.

Survey administration and data collection are still ongoing, and results analysis will begin after initial survey data are collected. Planned methods include data analysis by demographics breakdowns to analyze potential differences between groups of different age brackets, genders, first languages, and county of residence. Data processing and analysis will be conducted twice: once by us, and separately by appropriate members of EK staff, volunteers, and community leaders [4]. The purpose of this duplication is first to support EK representatives in conducting data analysis themselves, and second to gain multiple perspectives in the data, including from community members [4].

Future inquiry methods would provide additional value when no longer precluded by COVID-19 safety considerations. Surveys are valuable for grouped, predetermined responses, but qualitative methods such as focus groups and interviews provide more

nuance and may be more accessible to those with low literacy [3–12]. Town halls may also be more accessible for literacy considerations.

2.2. Financial Sustainability

This began with an internal and external assessment of organizational structure and strategy, existing cost and revenue streams, stakeholder and PESTEL(E) analyses (external environment and factors), and value chain mapping. We identified opportunities for growth and sustainability based on the assessment results, while considering potential challenges and risks, followed by a comprehensive and tailored financial sustainability road map. In our internal assessment, we relied on methods including semi-structured interviews and workshops with the client to understand the driving strategy, existing structures and processes, and financial statements. This was followed by a technical analysis where financial ratios were calculated and a numerical analysis was conducted. The lack of historical financial data imposed a challenge and only allowed us to do a snap-shot analysis for the year 2020. Furthermore, we initiated an outreach to experts to refine the general findings of the internal organizational and governance structure. The external assessment employed extensive research and workshopping with the client, and provided a targeted analysis of the legal environment given the radio's current legal status, socio-cultural nature of the island guided by workshops with the client, and political forces that can potentially influence the radio. Finally, we conducted selective market research based on available market reports [#] to understand the overall radio market in Kenya. This was followed by benchmarking for eight selected radio stations based on the location and content relevance, which identified the social media engagement and potential sponsors.

2.3. Partnership Strengthening

Building and strengthening partnerships between the radio and its strategic partners is especially pivotal to the radio's success given EK-FM's ongoing transition to Abakunta CBO ownership. The partnership strengthening aspect utilized stakeholder analysis to determine the radio's major partners. This was followed by an in-depth review of the existing organization agreements (MOUs and SOWs) with the aim of realigning the critical areas of collaboration between Abakunta and its partners. A case in point here is that Maseno University, with its rich array of programs and a dedicated academic community, presents a huge potential for a mutually beneficial relationship with EK-FM. Solidifying this relationship is currently a work in progress, but is likely to be successful given strong expressed interest from both partners. One of the important activities happening concurrently with the management transition to the new Abakunta CBO is bringing together the interim CBO board and the different relevant departments of Maseno University to discuss potential areas of collaboration.

Strengthening the relationship between Maseno University and EK-FM lies in the desire to build capacity within EK-FM through certificates and diploma programs in media and communication for the radio's staff, access to interns from the university, and personpower and resources universities can provide. Connecting with a local university offers an opportunity for Abakaunta and EK-FM to build a stronger support network with in-person or technological connections to students and instructors from across the country with various areas of expertise. A strong university connection may also further Abakunta's goal of community resilience by creating space for university students and staff to work alongside the communities on Mfangano.

There are stand-alone projects Maseno and EK-FM have collaborated on, but EK-FM desires a broader, long-term partnership. Forging sustainable and lasting partnerships between organizations requires time, trust, and setting expectations at the outset [14,15]. The relationship between EK-FM and Maseno University is currently linked through OHR; however, future partnerships will be between Maseno and Abakunta. We reviewed the existing Memorandum of Understanding (MoU) and determined which aspects should be carried forward into the new partnership and which aspects were missing. These

determinations were based on research about building lasting relationships between NGOs, CBOs, and universities. The findings from this review of the existing literature proposed that value propositions, clear goals and contact people, and mission alignment were critical in ensuring partnerships were sustainable [14,15]. Findings also recommended moving beyond project-based connections to a broader partnership that both parties could rely on [14].

We contacted leaders from Abakunta and department heads at Maseno University to gather information about desired avenues for collaboration, what each party expected from the relationship, and what they could provide. We asked questions about what each party expected from and could offer to the partnership. We also asked how each party expected the partnership would benefit Mfangano communities or Maseno students. These questions are important because they are avenues for aligning expectations from each party and intentions are clear at the outset of the relationship.

3. Results and Findings

This project is ongoing, thus the results presented in this paper are preliminary and the deliverables we are responsible for are in progress.

3.1. Community Engagement

An early community engagement deliverable was a pilot community inquiry survey. Questions were grouped into four sections: General, about the frequency and quality of listeners' experiences; Content; Presenters, about the radio presenters; and "About you" for age, gender, first language, and region of residence demographics. The final paper survey will be provided in both PDF and Google Forms format so it can be easily printed and so staff and volunteers can easily input data from paper surveys.

A description of the survey, its purpose, its voluntary nature, and assurance of its anonymity precede the paper survey, in non-academic language. Paper surveys will be administered by radio presenters en masse to households, and envelopes will be provided to protect respondents' privacy. Paper surveys can be returned to dropboxes positioned in strategic locations around Mfangano, such as next to previously set-up handwashing stations, or returned to a health navigator (another OHR program).

Additional mixed methods require fewer questions due to time and character restrictions. To that end, we identified questions that would be more appropriate for social media due to their general quality or translatability to an online poll. We also identified questions to broadcast with the potential for call-ins and/or SMS responses. In particular, separate surveys and feedback will be repeated during multiple programs about four key topics the radio covers (agriculture; health; education; and governance, politics, and leadership). The goal of this repetition is to receive feedback about specific topics from listeners who are known to be engaging with that topic (due to the synchronous nature of the survey).

Further deliverables will consist of a guide for structure and phrasing of community inquiry surveys, focus groups, and interviews to facilitate EK-FM staff and volunteers' capacities to design and administer surveys independently. This guide will also incorporate the ethical considerations of community feedback methods, namely compensating respondents for their time and resources when possible (especially in the case of interviews or workshops which may require more time and transport); incorporating methods to share grouped feedback results publicly, such as through paper fliers or on-air; and clarifying how and when feedback will be incorporated.

As this is a pilot, the various survey methods will also be assessed for utility and relevance of responses. We anticipate many aspects of the community inquiry methods will be adjusted in response to this pilot, including the data analysis process and survey questions based on the quality of responses in initial surveys. We also anticipate tracking the various methods of response gathering to evaluate and compare the utility of paper surveys, on-air SMS surveys, on-air call-ins, and social media methods. Considerations for COVID-19 safety also necessitate certain limitations on possible methods, so future

adjustments may also explore methods such as focus groups, interviews, town halls, and workshops as additional opportunities for feedback, including the utility of their responses. Consistent with the pilot project's mixed survey methods, we anticipate that community inquiry methods will provide more value to both EK-FM and the community if they continue to utilize varied methods as appropriate for the situation.

3.2. Financial Sustainability

3.2.1. General Operational Findings

The initial analysis of internal EK-FM documents showed that the vision and mission statements can be further developed to reflect EK-FM's new identity as it becomes independent from OHR. The development of these strategy statements can further guide the financial sustainability strategy and activities that align with the radio's vision and core values as a new separate entity [16]. Furthermore, the existing organization structure is built around the existing radio workforce, which does not allow for flexibility in growth. To address this issue, we developed a recommended functional organization structure where personnel can be allocated to one function or more as the radio team grows organically, as shown in Figure 1.

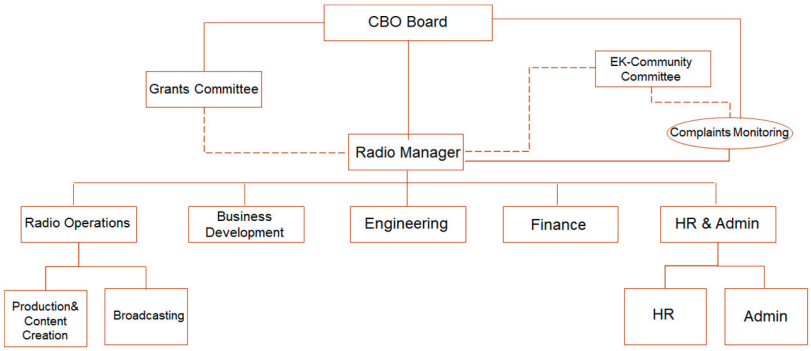

Figure 1. Recommended organizational chart.

In Figure 1, solid lines signify direct reporting lines, while dashed lines signify communication channels. We recommended including a Human Resources (HR) department that can coordinate interns from Maseno. This shows the interconnectedness of the three components of this project as working with Maseno interns is a key component of partnership strengthening. The HR department should also be responsible for complaint handling and report directly to the radio manager. To ensure sensitive complaints are handled, we suggest having a complaint box to accept anonymous and non-anonymous complaints. A Complaint M&E team would monitor HR's handling of complaints through focus groups, surveys, or interviews, and report to management directly. We suggested someone from the EK Community Council with relevant experience to perform HR department audits when applicable. We also recommended the radio team revise all job descriptions based on the recommended functional organization structure, avoid the use of unquantifiable action verbs such as "take care", and develop Key Performance Indicator(s) with quantifiable metrics.

3.2.2. Cost and Revenue Stream Analysis

A cost stream analysis for 2020 showed spikes in expenditure associated with bonus payments, generator repairs and fuel, and licensing and royalties. A total of 73% of licensing fees, royalties and copyrights cost went to music and other copyrights fees. This highlighted the importance of optimizing royalties' payments. The total cost for running the generator over 6 months, including fuel and repairs, was near 180 k KES. We recommend looking for more resilient and additional economic options, especially considering fuel may not be easily accessible in emergency and isolation disasters.

Regarding revenue, our analysis showed only 42% of 2020 spending has been financed by radio-generated income, 58% of revenue is from grants, and only 1% is generated from advertisements. Our recommendations highlighted the importance of pursuing other revenue streams because grants constitute more than half of revenue and they are not as sustainable as other revenue sources. Additionally, one sponsoring NGO contributed 59% of the income generated by sponsorships. This should guide the targeting approach and push for an agreement with this organization, if applicable.

The Kenyan radio market is fragmented with small players holding over 30% of the market, and the four biggest players holding around 41% of the market [17]. EK-FM is a niche community radio; therefore, big market players are not a threat. However, low barriers to entry should be considered a threat and ad pricing can be set and manipulated by the big players. The eight radio stations used for benchmarking indicate social media reach is important; for example, each of the eight radios has hundreds of thousands of Facebook likes compared to EK-FM's likes of around 4000. Benchmarking analysis showed the main sectors using radio ads and sponsorship are the government, NGOs, banks, corporations, sports brands, and religious entities.

3.2.3. Recommendations

Our first recommendation was to allocate more resources to secure more sponsorships and advertisements to gradually fill in the gap between revenues and costs in the absence of future grants. Table 1 presents potential revenue streams.

Table 1. Initiatives for capitalizing on the advertisements and sponsorships as a potential revenue stream.

Initiative	Key Metrics	Potential Risks/Bottlenecks	Relevant Findings
Identify targeted sectors to promote EK-FM capacity for advertisements	# of sectors; Month to month change in # of meetings w/potential sponsors	Mis-categorize sectors' perception of EK-FM	Telecom industry, local vendors, governments, NGOs and hotels
Assemble a business development (BD) team	Status of BD team; # of personnel w/BD activities	Budget constraints; skilled personnel scarcity; no direction	Function is included in the recommended organizational chart
Develop promotion and advertisement packages and pricing (Rate Cards)	Availability of the rate card; percent growth of distribution channels of rate card	Lack of personnel; lack of market pricing awareness	Sample rate cards identified. Card value guided by market rates
Engagement with previous EK-FM sponsors/clients and formalizing agreements	percent of clients contacted; # of agreements formalized; percent of radio revenue pledged	Previous sponsors change policy and exclude radio sponsorships	EK-FM has experiences with NGOs to be capitalized on as potential quick wins
Approach identified clients systematically	Monthly change in # of meetings w/ prospects; percent of meetings leading to revenue	Lack of motivation; relevance of unique EK-FM selling points	Social media is important; top 8 radios have 100,000 s Facebook likes, EK-FM, 4000
Increase social media engagement	Month to month change in the # of Facebook page likes; frequency of Facebook posts	Internet accessibility on island; capacity shortage; content relevance	EK-FM uses Facebook for outreach. More posts and active marketing is possible

Our second recommendation focused on using the unique opportunity EK-FM has given its unique structure and access to resources as the sole program under the Abakunta CBO. This can allow for two potential revenue generation models:

1. Abakunta can start a money generating program that also provides job opportunities, and use income generated from this program to support EK-FM activities. We have been informed EK has operated an organic farm with two main objectives: providing the community with healthy food and generating income for EK.

2. Utilize the radio as a marketing channel for local vendors' open days, where EK-FM uses rent-free land it operates to provide a market space for vendors for a fee. Vendors obtain space and higher market penetration due to the radio's systematic activities of promoting the event, vendors, and location.

3.3. Partnership Strengthening

The partnership strengthening aspect of the project is in its early stages, thus the deliverables for this process are in their preliminary forms. At the moment, verbal commitments have been made and both parties are working on their value proposition, which will then be formalized into more detailed, action-based agreements (MOUs and SOWs) that explicitly reflect the needs of the radio than the previous ones. Additionally, after conducting research on sustainable partnerships between CBOs and universities, a report was compiled and presented to the Abakunta board. This report included recommendations for Abakunta to follow when working with Maseno University. Recommendations included designating a certain person at the CBO to manage the partnership (as mentioned earlier, this should be managed under the HR position in the recommended organizational chart), locating multiple people at Maseno to connect and build relationships with, creating a knowledge documentation system both parties have access to which will allow the two-way transfer of information, and creating a separate financial account for this partnership. Potential areas of collaboration were also presented and recommended to actors on both sides of the prospective partnership for consideration, including radio listener base identification; Maseno interns at EK-FM for various projects; training and capacity building certificates and diplomas from various Maseno departments for EK-FM staff; training, research and learning opportunities to Maseno University scholars at EK-FM.

4. Conclusions

This is a specific case of CBO strengthening in western Kenya using the strategies within three project areas. Community engagement and inquiries ensure the CBO is working for the people it serves and considers their needs and desires while expanding. Financial sustainability activities, including the systemic assessment of the radio combined with benchmarking activities of the Kenyan radio market, allowed for the identification of areas of improvement and optimization on both strategic and financial levels. For EK-FM, capitalizing on the vibrant Kenyan radio advertisements market and taking advantage of the radio governance structure to build revenue-generating business units suggests promising approaches to achieve financial sustainability. Partnership strengthening can lead to more personpower and resources, which in turn can assist in Abakunta's vision of community resilience. Although these pathways are applicable for Abakunta and EK-FM, there are other routes available to other CBOs looking to expand or step away from a parent organization. Additionally, the entirely virtual role of our team presents advantages for Abakunta as they expand as a Kenyan-led and -operated organization because the neo-colonial OR hegemonic influence of US institutions leading development interventions is further removed and it is easier for them to claim ownership over project processes. Finally, our endeavors demonstrated that certain projects as this one can be conducted completely virtually. The onslaught of videoconferencing and other technological advancements make community development projects doable from any location, replacing the need to travel to work physically alongside community and organizational leaders.

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Proceeding Paper

Sustainable Development Scenarios for Urban Blocks: Energy Renovation and Quality of Life in the Greek City †

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Abstract: SDG11–Cities and Communities aims to renew and plan cities and other human settlements so that they offer opportunities for all, while improving resource use and reducing environmental impacts. This research examines the regeneration of urban blocks as a means for improving the overall quality of life in Greek cities. The objective of the research is to determine the energy and economic efficiency of four building renovation interventions, including conventional energy upgrading—such as building shell thermal insulation—and more intensive solutions, such as phase change materials, green roofs, and passive solar system integration. The research methodology combines dynamic simulations with Energy Plus simulation software and an economic evaluation of the interventions as well. The results prove that the reduction in energy demand can vary between 55.7% and 59.1% according to the renovation scenario, while the cost of each intervention varies from 73 to 347 EUR/m^2, proving that the payback period of each scenario largely depends on urban block form. The findings of the research can be useful in defining the most efficient renovation strategies at the urban block scale and to promote urban sustainability.

Keywords: building renovation; urban block; urban regeneration; energy efficiency; economic assessment; cost of renovation; payback period

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1. Introduction

The new EU strategy for "A Renovation Wave for Europe—Greening our buildings, creating jobs, improving lives" [1] and the European regulations, which are setting stricter energy efficiency targets for the improvement of new and existing buildings, are leading the way of cities toward a climate neutral Europe until 2050 [2]. SDG11–Cities and Communities aims to renew and plan cities and other human settlements so that they offer opportunities for all, while improving resource use and reducing environmental impacts [3].

Mediterranean cities face many challenges concerning their sustainable development. The mild Mediterranean climate compared to that of the European central or northern countries and the fact that there are longer periods of solar availability [4] favor both the lower energy demand for the heating of buildings and the higher potential for renewable energy sources installations. According to the SDG7–Affordable and Clean Energy Indicators, Greece's share of renewable energy in 2018 (18.05%), was above the European mean [5]. However, the dependency of the country on energy imports from other countries (70.68%) is much higher than the European mean (58.19%), while 22.7% of the population still fails to keep their home warm [5].

The bad condition of the Greek building stock [6], which has not been renovated for many decades, together with the fact that passive design and renewable energy installations have not been considered for older buildings, has resulted in a high energy footprint for the building sector. At the same time, the low construction quality of buildings has negative

effect on the inhabitants' quality of life, including low standards of noise protection and low aesthetics.

However, the way to a sustainable renovation practice is cost dependent [7], as the initial capital needed for the building interventions is in many cases not affordable for the owners. On the other hand, there have been many incentives and state subsidies trying to promote building renovation, mainly in terms of the energy upgrading [8,9]. These strategies have mainly promoted building insulation and heating systems equipment replacement with more efficient ones. More intensive passive strategies have been rarely considered as the additional cost of such interventions is often considered as a barrier their construction.

In November 2021, the Commission launched a call to cities to join the European Mission on Climate-Neutral and Smart Cities. The objectives of the mission are to achieve 100 climate-neutral and smart European cities by 2030 and to ensure that these cities act as experimentation and innovation hubs to enable all European cities to follow suit by 2050 [10].

The opportunity for EU cities to participate and promote their climate neutrality by 2030 could be an ambitious target. The eight-year horizon for achieving climate neutrality means that it is necessary to set efficient strategies in order to reach the goal by 2030.

Many renovation technologies, solutions, and smart strategies have been applied at the building scale—including conventional or more innovative materials, passive solar systems, renewable energy installations, etc.—in order to improve the energy performance of buildings, as the renovation of the building stock is a major contributor toward climate neutrality. However, the building scale is a rather small scale to reach a large impact toward climate neutrality, especially in a shorter time horizon.

The consideration of larger-scale interventions can be proved an appropriate solution in terms of faster, more efficient, and better integrated renovation of the building stock. This research aims to prove that the examination of renovation interventions at the urban block scale has many advantages as it can be better oriented toward the most energy-demanding urban areas, it can provide an economy of scale including both limiting cost and renovation time and effort, and it can contribute to the regeneration of the overall image of the city as well.

Under this perspective, this research analyzes the energy efficiency of four passive energy upgrading interventions implemented at the urban block scale aiming to, on the one hand, examine the contribution of urban block form on the energy performance before and after renovation, and, on the other hand, define the degree to which the investment of the renovation can be translated into an economic value.

As urban block form has been proved to affect the energy performance of heating and cooling of buildings [11], it is expected that it can also significantly affect the economic efficiency of the interventions.

This research aims not only to define the additional cost in comparison to the conventional renovation intervention (exterior thermal insulation), but also to define the payback period of each renovation scenario.

The results of the research can prove that some passive interventions have a short payback period, which makes them more sustainable from an economic point of view, while others have longer payback period as the cost of materials stays relatively high. This means that it is necessary to examine the energy savings together with the initial cost of the interventions and the payback period in order to define their overall efficiency and sustainability.

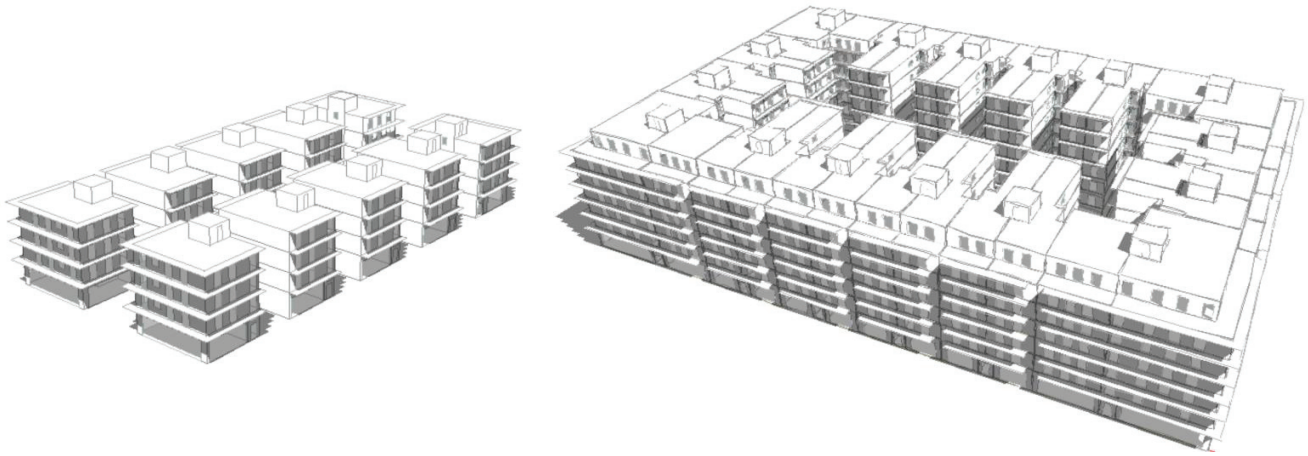
2. Materials and Methods

The examined cases are described in this section. First, the initial condition of the urban blocks is presented and, second, the four intervention scenarios are described.

The methodology for assessing energy demand and cost of all cases (initial condition and renovated scenarios) is analyzed.

2.1. Description of the Examined Cases

The research examines two typical residential urban blocks representing the existing form of the built environment of a Greek city (Figure 1a,b).



(**a**) (**b**)

Figure 1. (**a**) Perspective view of urban block 1 and (**b**) perspective view of urban block 2.

The first urban block has four floors while the second has seven floors. All building elements of both urban blocks are considered to be non-insulated, according to the majority of buildings that were built before 1980 in the centers of Greek cities.

Across all EU Member States, most of the floor area is composed of residential buildings. Greece has a relatively large share of residential buildings (84.21%). The share varies considerably, from around 60% in Slovakia, the Netherlands, and Austria, to more than 85% in the southern countries of Cyprus, Malta, and Italy. Moreover, the percentage of multifamily buildings (65.21%) in Greece is also one of the largest in Europe after Poland, Spain, Italy, and Estonia [12].

According to the results of the 2011 building census, 58.35% of buildings in Greece were built before 1980 and 58% of the total buildings' main construction system is reinforced-concrete load-bearing structure and brick masonry walls. Among these buildings, 61% are attached to the neighboring buildings [13]. A more detailed study of the typical urban block in the Greek city can be found in [11,14].

The two examined urban blocks are assumed to have a typical construction system of reinforced-concrete load-bearing structure (u-value = 3.25 W/m^2K) and brick masonry walls (u-value = 1.72 W/m^2K). For the horizontal building elements, the u-value of the roof slab is assumed to be 2.11 W/m^2K, the u-value of the concrete slab on ground is 2.65 W/m^2K, and for the slabs between floors, the u-value is 2.74 W/m^2K. Windows are single glazing with a u-value of 5.81 W/m^2K. It should be noted that both urban blocks are examined for the climatic conditions of Zone C, which is the second coolest zone in Greece according to the national Energy Performance of Buildings Regulation [15]. The two examined urban blocks are considered to have a retail use on the ground floor, while all other floors are assumed to have a typical layout plan with residential use. Urban block 2 has a recessed last floor (by 2.5 m), resulting from the current practice required by the Building Regulation in Greece for narrow street canyons. In this study, the road width is assumed to be 10 m.

2.2. Renovation Strategies

Four renovation scenarios were considered for the assessment of energy and economic efficiency of the interventions.

The first includes the typical insulation of the building shell by adding a thermal insulation layer at all the exterior surfaces and all surfaces facing non-heated spaces

(Figure 2b). Windows are also replaced with new double-glazed ones. It should be noted that the other three scenarios are also considered to have been upgraded according to scenario 1, and the interventions described next are additional interventions to already thermally insulated buildings.

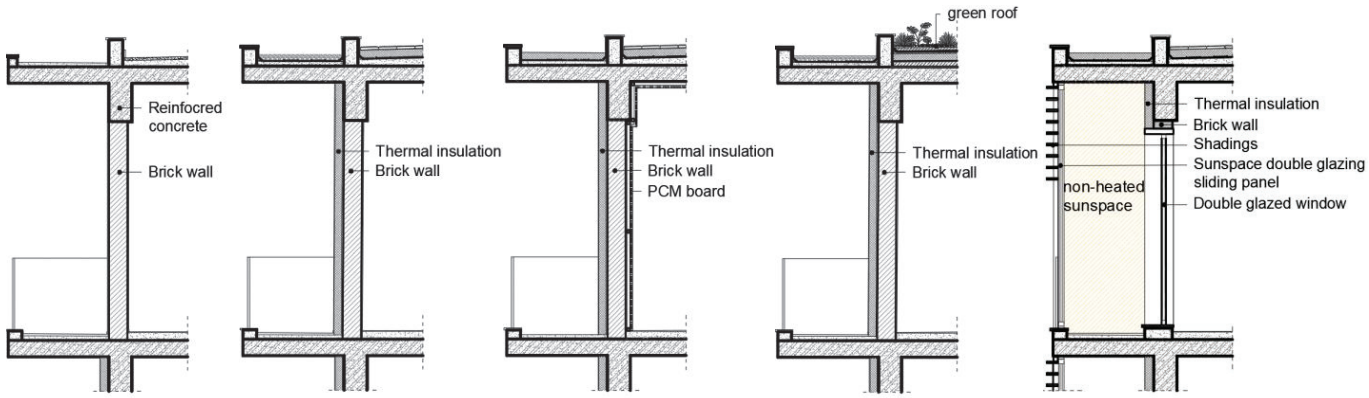


Figure 2. Construction details of the base-case scenario and of the renovation scenarios: (**a**) initial condition of buildings (base-case scenario); (**b**) intervention scenario 1: thermal insulation; (**c**) intervention scenario 2: PCM; (**d**) intervention scenario 3: green roof; (**e**) intervention scenario 4: passive solar and shading.

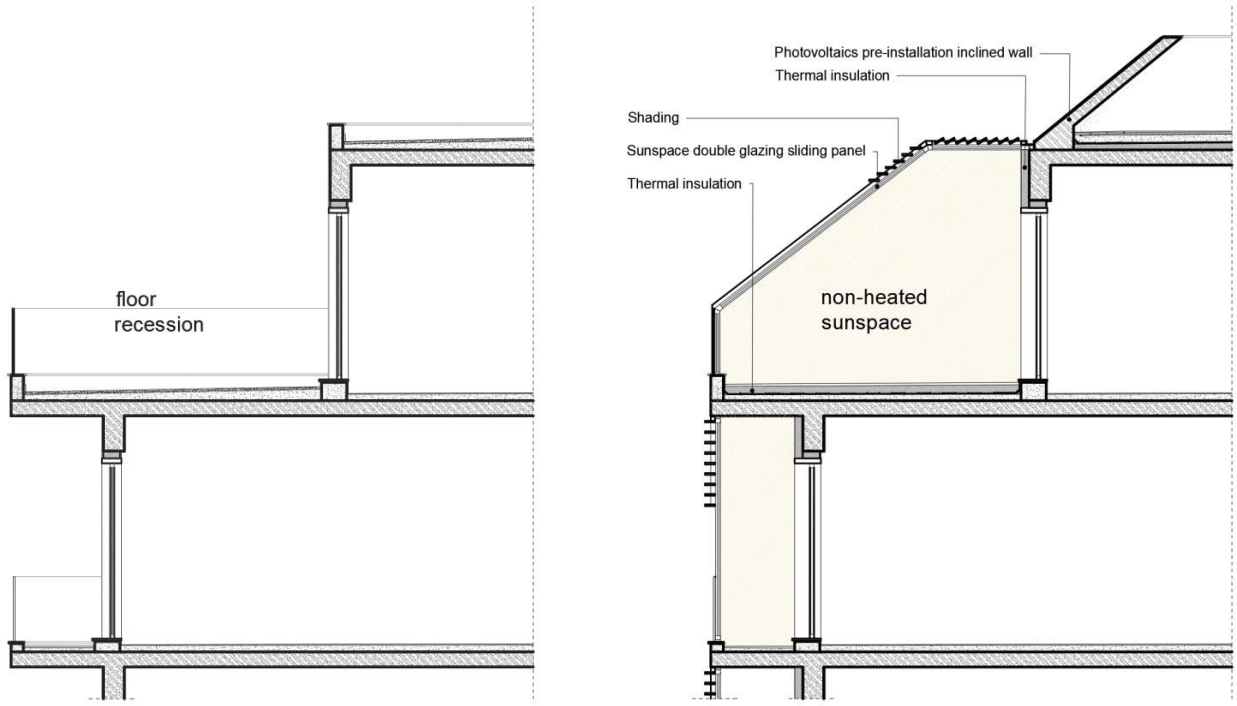
The second scenario includes improvement of the thermal mass of the building shell by adding a 3 cm PCM board with a melting point at 25 °C in the interior side of all exterior walls and ceilings (Figure 2c).

The third scenario includes the construction of a green roof on the last floor slab of all buildings (Figure 2d).

The fourth scenario includes the addition of sunspaces and shading on building facades. Sunspaces are added on the balconies of the last floor of the first urban block and the last two floors of the second urban block. Sunspaces are deactivated during the summer by sliding the glazing parts on the sides. Shading includes horizontal blinds in the exterior shell, outside of all sunspaces (Figure 2e).

All the construction details of the existing and the renovated building shell scenarios are presented in Figure 2a–e for urban block 1. Figure 3a,b presents the existing (base-case) and the renovation scenario 4 (passive solar and shading) for urban block 2. Scenarios 1–3 are not presented for urban block 2 as the construction details are similar to the details of urban block 1, except for the geometry of the section.

For all four scenarios, the u-values of all building elements after the renovation are considered to be equal to the maximum permitted values given by the Greek Energy Performance of Buildings Regulation (KENAK) [15]. According to the regulation's limits, the u-values for the exterior walls should not exceed 0.45 W/m^{2}K. For the horizontal building elements, the u-value of the roof slab should be no larger than 0.40 W/m^{2}K. The u-value of the concrete slab on ground should be up to 0.75 W/m^{2}K. Windows should be double glazed with a u-value no larger than 2.80 W/m^{2}K.



(**a**) (**b**)

Figure 3. Construction details of the (**a**) base-case scenario and (**b**) renovation scenario 4 (passive solar and shading).

2.3. Assessment Methodology

For the energy efficiency assessment of the urban blocks, dynamic simulations with the Energy Plus 9.1.2 software were performed. First, the total load demand for the heating and cooling of buildings was calculated for the base-case scenario, representing the existing situation of the buildings, and then three renovation scenarios were also simulated to define the improvement of the energy performance during the whole year period.

For the assessment of the economic cost of the interventions, all the surfaces of all building elements used in each renovation scenario were calculated. Then, the value—including material and construction cost of each building element—was set according to Greek market values from well-known companies. The economic cost values were also verified through relevant literature [16,17]. Tables 1 and 2 present the calculated surface areas of each element included in each intervention scenario and the cost in EUR/m^2, including material and constructional cost for both urban blocks.

Table 1. Building element quantities for urban block 1 and cost per m^2 for each intervention.

Zone	Building Element	Interventions	Net Area	Renovation Scenario			
			m^2	1	2	3	4
				EUR/m^2			
Residential, Retail	External Brick Wall	Insulation, PCM	5495	55	40	-	-
	External Ceiling	Insulation, PCM, Green Roof	1152	40	40	50	-
	Ground Floor	Insulation	1152	40		-	-
	Internal Ceiling	PCM	3343	-	40	-	-
Staircase [1]	Internal Concrete Wall	Insulation, PCM	1411	20	40	-	-
	External Ceiling	-	148	-	-	-	-
	External Concrete Wall	-	269	-	-	-	-

Table 1. *Cont.*

Zone	Building Element	Interventions	Net Area	Renovation Scenario			
				1	2	3	4
			m^2	EUR/m^2			
Entrance [1]	Internal Brick Wall	Insulation, PCM	150	20	40	-	-
Elements in all zones	Windows	Windows	1187	180	-	-	-
	Sunspace	Sunspace and Shadings	735	-	-	-	180
	Shadings	Sunspace and Shadings	818	-	-	-	220

[1] non-heated space.

Table 2. Building element quantities for urban block 2 and cost per m^2 for each intervention.

Zone	Building Element	Interventions	Net Area	Renovation Scenario			
				1	2	3	4
			m^2	EUR/m^2			
Residential, Retail	External Brick Wall	Insulation, PCM	18,278	55	40	-	-
	External Ceiling	Insulation, PCM, Green Roof	4503	40	40	50	-
	Ground Floor	Insulation	4235	40	-	-	-
	Internal Ceiling	PCM	19,705	-	40	-	-
	Internal Brick Wall	PCM	9565	-	-	-	-
Staircase 1	Internal Concrete Wall	Insulation, PCM	3921	20	40	-	-
Entrance 1	Internal Brick Wall	Insulation, PCM	986	20	40	-	-
Elements in all zones	Windows	Windows	4233	180	-	-	-
	Sunspace	Sunspace and Shadings	1989	-	-	-	180
	Shadings	Sunspace and Shadings	2358	-	-	-	220

[1] non-heated space.

Next, the payback period of each intervention was assessed by taking into account the savings resulting from energy demand in each renovation scenario and the current price per KWh in Greece.

3. Results

For the assessment of the economic efficiency of each intervention it is necessary to define the improvement in terms of the energy savings it can provide. The total energy demand for heating and cooling was calculated for both urban blocks through simulations and is presented in Table 3. It should be clarified that the simulations at this stage of the research include only the thermal demand (heating and cooling) per m^2 on a yearly basis and not electricity consumption. It is remarked that in all cases urban block 2 performs better in terms of energy consumption as the total energy demand is lower for the base-case and the renovation scenario as well. It should also be noted that scenario 2 (PCM) is the most efficient in terms of energy demand for urban block 1, while scenario 4 (passive solar and shading) is the most efficient intervention for urban block 2. However, to determine which intervention is more efficient on an economic basis as well, it is necessary to calculate the cost in each case for constructing each scenario.

The economic evaluation of each intervention scenario for both urban blocks is presented in Tables 4 and 5. It is obvious that the cost of renovation for both examined cases is higher in scenario 2 (PCM). This is because this renovation scenario includes the most extensive interventions (in terms of surface), as PCMs are applied in all exterior walls and all ceilings (exterior and interior).

Table 3. Total energy demand (in KWh/m^2) for the heating and cooling of the base-case and the renovation scenarios for the two urban blocks.

Urban Block	Base-Case	Renovation Scenario Total Energy Demand (KWh/m^2)			
		1	2	3	4
1	214.54	95.01	91.20	93.40	92.10
2	185.39	79.35	76.58	78.79	75.90

Table 4. Total cost of the renovation scenarios for urban block 1.

Scenario	Renovation	Net Area (m^2)	Renovation Cost (EUR)	Total Scenario Cost (EUR)
1	Insulation	9361	425,625	-
	Windows	1187	213,660	-
				639,285
2	PCM	23,103	924,138	1,563,422
3	Green Roof	1152	57,595	696,880
4	Sunspaces	735	132,300	-
	Shadings	818	179,960	-
				951,545

Table 5. Total cost of the renovation scenarios for urban block 2.

Scenario	Renovation	Net Area (m^2)	Renovation Cost (EUR)	Total Scenario Cost (EUR)
1	Insulation	31,923	145,2950	-
	Windows	4233	761,940	-
				2,214,890
2	PCM	11,3916	4,556,640	6,771,530
3	Green Roof	4503	225,150	2,440,040
4	Sunspaces	1989	358,020	-
	Shadings	2358	518,760	-
				3,091,670

Moreover, as expected, the total renovation cost for all scenarios is higher in urban block 2 due to its larger size. However, if the cost is calculated per m^2, it is obvious that urban block 2 has a significantly lower cost for the construction of all scenarios (Table 6). The cost of all interventions is between 36% (scenario 2) and 52% (scenario 4) lower for urban block 2.

Table 6. Cost per m^2 for all renovation scenarios for the two examined urban blocks and percent difference between the two cases.

Renovation Scenario	Cost (EUR)/m^2		Percent Difference (%)
	Urban Block 1	Urban Block 2	
1	142	73	49
2	347	223	36
3	154	80	48
4	211	102	52

To assess the economic sustainability of the renovation scenarios, the payback period was calculated assuming that the cost of energy stays unchanged during the years (Table 7)

and equal to 0.11 EUR/KWh, which is the cost of electric energy given by the national energy provider (DEI). In both cases, the first renovation scenario (thermal insulation) has the shortest payback period compared to the other three renovation scenarios. It should also be noted that PCM scenario (2) has the longest payback period, which can be explained by the fact that it is the most extensive intervention because it is applied in all floors (walls and ceilings). Moreover, buildings are characterized by heavyweight construction in their initial situation as they are constructed by reinforced-concrete load-bearing structure and brick masonry walls, which means that the additional thermal mass provided by the PCM may not be as efficient as other interventions.

Table 7. Payback period of each intervention scenario for the two urban blocks.

Urban Block	Payback Period (years)			
	Renovation Scenario 1	Renovation Scenario 2	Renovation Scenario 3	Renovation Scenario 4
1	11	25	12	16
2	6	18	7	8

The comparison of the examined urban blocks shows that urban block 2 has a significantly shorter payback period in all scenarios. Especially for scenario 4 (sunspaces and shading), the payback period is halved for urban block 2. This can be explained considering that this urban block has a different geometry in the last floor (recession) that favors the integration and efficiency of sunspaces.

4. Discussion

This research investigated the energy upgrading interventions at the urban block scale. The environmental efficiency (in terms of energy consumption) and the economic effectiveness of the interventions were assessed.

The results of the research showed that urban form can significantly affect not only the energy efficiency but also the economic effectiveness of renovation. Therefore, urban block form is an important parameter to consider before planning any renovation strategy. Among the two urban blocks examined, the one with the larger size and the more compact form was proved to be more efficient in terms of energy, demanding less energy for heating and cooling. Moreover, it was proved that in this urban block all renovation interventions present better economic effectiveness because initial capital depreciation occurs significantly earlier, from 5 to 7 years, depending on the renovation scenario.

Among all the examined interventions, the PCM was less efficient due to the prohibitive cost of construction and the exceedingly long payback period. Therefore, it is not a recommended strategy in a Mediterranean climate, a result that has also been shown by other researchers [18]. However, in this study, the PCM chosen was targeted to improve the heating load demand during winter according to the melting point temperature chosen, as this solution was calculated to contribute more to the overall yearly energy demand. Other researchers, investigating PCM integration during the cooling period for the Mediterranean climate, reached mixed results [19], as it depends on appropriate design of the PCM integration and the building's inertia.

Green roofs have been calculated to be a very efficient scenario (after the conventional building shell insulation scenario 1), as it has a short payback period, mainly due to its relatively limited initial investment cost.

Passive solar systems have also been proved a very efficient renovation strategy for the Greek climate, as the systems can provide significant energy savings, a result also supported by other research in a similar climate [20], while at the same time they can also foster the quality of life in cities by providing improved indoor sound quality, and the ability to improve building aesthetics.

The work proposed could be further expanded by examining more typologies of urban blocks to be able to generalize the results for larger urban areas, while at the same time it could also include RES system installation at the urban scale in order to assess renovation strategies targeted toward nearly zero energy buildings (nZEBs). The results of the research are useful for defining large renovation priorities at the city scale and for introducing specific solutions for the retrofit of buildings.

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Proceeding Paper

Review of Impacts on Sustainable Development in Ecuador of the COVID-19 Pandemic and Lockdown Measures †

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Abstract: The COVID-19 pandemic has put pressure on Ecuador's Government and affected its ability to achieve its Sustainable Development Goals. This literature review shows the impacts of the pandemic and lockdown measures on SDGs 1, 3, 4, and 8 in Ecuador, with an individual focus on poverty, health, education, and the economy. The timeline used to analyze the impacts of COVID-19 in Ecuador is the period 2015–2020. The results show that measures were not effective in controlling the pandemic, according to the ECE (Epidemy Control Efficiency) indicator. Unemployment, poverty, and extreme poverty increased. Ecuador faced Dengue disease at the same time as the COVID-19 pandemic. Efforts to establish tracking and early diagnosis of COVID-19 were hindered due to a shortage of testing. Furthermore, effective learning through virtual education was difficult for the 74.7% of households without an internet connection. In general, the pandemic set back Ecuador's progress towards the SDGs analyzed.

Keywords: COVID-19; Ecuador; health; SDGs; economy

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1. Introduction

In March 2020, the Director-General of the World Health Organization (WHO) classified the COVID-19 outbreak as a global pandemic and asked countries to increase their actions to mitigate the spread of the virus and protect people [1]. As COVID-19 infections began to be reported worldwide, many countries responded by shutting down places such as schools, workplaces, and international borders to contain the spread of the virus. Based on this news, Ecuador took measures to safeguard and prevent possible widespread contagion in the population.

Due to the number of COVID-19 cases, the National Emergency Operations Committee (COE-N, in Spanish), on 16 March 2020, declared a state of exception due to public calamity throughout the national territory [2]. COE-N is the mechanism of the decentralized national risk management system, responsible for promoting, planning, and maintaining coordination and joint operation in emergencies or disasters with the different actors at a national level. It is directed by the President of the Republic of Ecuador or his delegate. Until 19 April 2021, there were 361,000 cases in Ecuador and 17,703 deaths due to COVID-19 [3].

On 17 March 2021, Ecuador received 84,000 doses of COVID-19 vaccines through the COVAX Facility [4]. The first vaccines to arrive were used to protect priority groups and those most at risk, such as health workers and older adults. To date, 27 July 2021, the total number of doses administered is 9,880,401, the fully vaccinated people 2,028,931, and the percentage of the population fully vaccinated represent 11.8% [5].

The COVID-19 crisis, linked to the implementation of health measures and social distancing to contain the spread of the virus, caused the total or partial closure of economic activities, affecting Ecuadorians' economy and daily life. The country's commerce industry, tourism, transportation, and health sectors have suffered the most. In addition, the loss of jobs and income increased the number of families living in poverty and extreme poverty. The present study consists of a review of the available literature on the impacts of the COVID-19 pandemic and lockdown measures on SDGs 1, 3, 4, and 8. The SDGs and the specific targets analyzed are 1.1, 1.2, 3.3, 3.D, 4.a, 8.1, and 8.5.

This research can serve different levels of government, so public policies are designed and executed that contribute to the protection of the vulnerable populations affected by COVID-19. In addition, this review contains valuable information available for academia, the private sector, and civil society in the different economic reactivation projects for the country.

2. Methodology

A bibliographic review was carried out in this work within the context of COVID-19 and the lockdown measures in SDGs 1,3,4, and 8. Data and information were taken from primary sources such as scientific articles and pertinent government entities. Theoretical foundations are structured to establish the possible effects on poverty, health, education, and the economy.

For a quantitative estimation of the efficiency of COVID-19 epidemic control in Ecuador [6], Epidemic Control Efficiency (ECE) was determined using Equation (1):

$$ECE = \left[\frac{R_0 - ERR}{R_0}\right] - \left[\frac{G_0 - G_t}{G_0}\right] \quad (1)$$

where, R_0 is the basic reproductive number, ERR is the effective reproductive number, and G_0 and G_t refer to the mobility factors. The time frame established for the calculation was the first 14 days after the first case of infection was confirmed.

3. Results

ECE determination is used in the 2020 Report of Sustainable Development to measure how mobility restrictions affected the infection rate in the early stages of the pandemic [6]. A similar estimation to this is presented in Table 1. The ERR value used was 3.95 [7], which corresponds to the period in which Ecuador confirmed 25 cases in the country. For the basic reproductive number, two values were used: 2.4, the mean used in the Development Co-operation Report 2020 for the Organization for Economic Co-operation and Development (OECD) [8] countries, and 2.93, a value estimated by Fernández et al. (2021) [9] by using maximum likelihood estimation. The mobility factor was calculated from Google Mobility Reports [10] in the first 14 days of March 2020 concerning mobility to workplace. Finally, the estimation of the epidemic control efficiency for Ecuador was calculated using Equation (1) and the results are reflected in the last column of Table 1. Additionally, in Table 1, the variables needed for the calculation ERR, R_0 and Mobility Reductions are listed along with their respective sources.

Table 1. ECE Determination.

ERR	R_0	Mobility Reduction	ECE
3.95 *	2.4 **	67% ****	−1.31
3.95 *	2.93 ***	67% ****	−1.01

Sources: * Caicedo-Ochoa et al. [7]; ** Sustainable Development Report [6]; *** Fernandez-Naranjo et al. [9]; **** Google Mobility Report [10].

3.1. SDG 1

Generally, poverty is considered a social phenomenon caused by a lack of resources. Internationally, a person is poor by income when he lives with less than 1.90 USD per day, known as the poverty line. At the National level, the poverty line of 2020 is at 84.1 USD per month. The extreme poverty line is at 47.4 USD per month [11]. The data so far (see Figure 1) indicates that poverty increased by 3.5 percentage points and extreme poverty by 1 percentage point from 2017 to 2019.

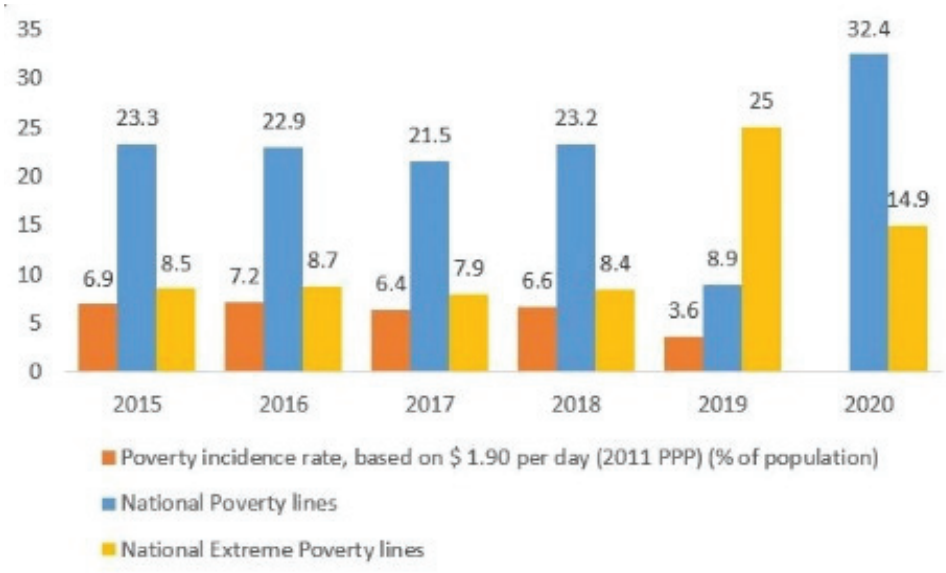

Figure 1. Percentage of population living under national and international line of poverty [12].

In 2020, the poverty rate at a national level was at 32.4% and the rate of extreme poverty was at 14.9%. Both have maintained an increasing tendency since December 2018 (see Figure 1). According to Ecuador's Central Bank (BCE in Spanish), by sex, the incidence of poverty was at 31.6% for men and 33.1% for women; these numbers have also increased since 2018 [11].

Therefore, by Executive Decree 1022, the Ecuadorian Government established the Family Protection Bonus for Emergency due to COVID-19, which involves the transfer of USD 120.00, paid in two equal parts between April and May. This bonus could be accessed only by those affiliated with the Rural Social Security and those affiliated with the Unpaid Work at Home Regime, and by those with an income less than 400.00 USD per month, on the basis that no member of the family group receives any Monetary Transfers granted by the Ministry of Economic and Social Inclusion (MIES, in Spanish) [13].

3.2. SDG 3

The COE-N presented the 72nd report about the national epidemiological situation due to COVID-19 [14]. This report shows the evolution since the beginning of the pandemic in Ecuador and the weeks that saw a maximum increase in contagion (Figure 2).

Dengue is a disease transmitted by vector *Aedes aegypti.* In the year 2015, there were 42,459 reported cases, the highest in the last five years, due to the co-epidemic of Chikungunya disease, another vector transmitted disease [16]. On the other hand, while there were 14,159 reported cases in 2016 and 11,387 in 2017, cases decreased in 2018 and 2019, with only 3,094 and 8,416 cases, respectively.

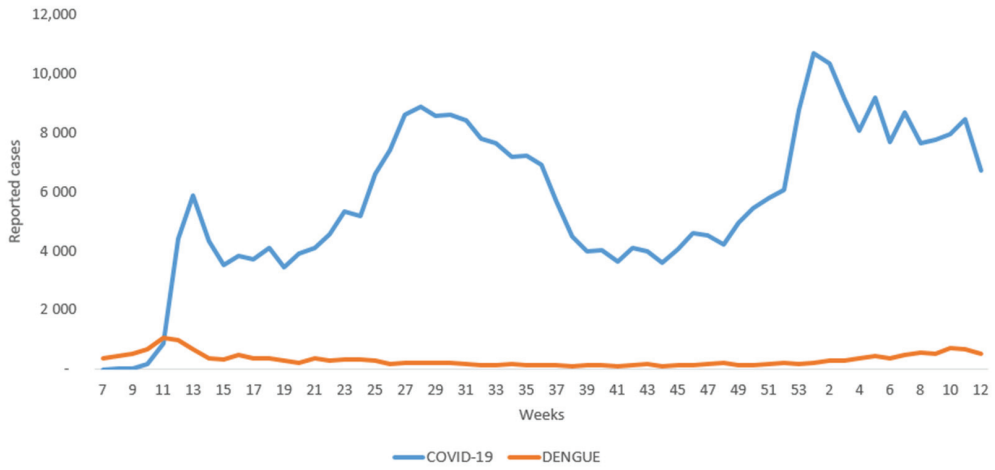

Figure 2. COVID-19 and Dengue reported cases from week 7 to 53 of 2020 and weeks 1 to week 13 of year 2021 in Ecuador. Source: Ministry of Health [15].

During 2020, there were 16,570 cases reported [17,18]; most Dengue Cases were published a couple of weeks before the peak of COVID-19 in Guayas, a coastal province. Figure 2 compares the reported cases of Dengue during the start of the pandemic and weeks 1 to 13 of 2021, when the highest number of reported cases occurred within the weeks ten until week twelve, which is the month of March. Said weeks are the end of the hot and rainy season in which the likelihood of the spread of juvenile *Ae. aegypti* increases [16].

Due to the similarities between COVID-19 and Dengue during their early stages, they are difficult to distinguish; they share similar clinical and laboratory features early on [19–24]. Dengue disease can be misdiagnosed due to these similarities. Similarly, Singapore and Thailand have reported cases where COVID-19 was misdiagnosed with a false positive result from Dengue serology testing [24,25].

SARS-CoV-2 testing in Ecuador proved to be complicated on a large scale. Testing took place mainly in the three largest cities of the country, while many rural communities comprised 1.1% of the population tested [26]. According to COE-N, the number of samples processed nationwide only corresponded to the cases detected through RT-PCR tests, which define the confirmed and discarded category due to COVID-19. This indicator corresponds to the total number of tests carried out by the laboratories authorized to process them. In Ecuador, from 29 February 2020 to 6 April 2021, 1,166,467 samples for COVID-19 were taken from RT-PCR tests, obtaining 337,702 confirmed cases according to the date of onset of symptoms [14]. Unfortunately, the number of confirmed deaths of COVID-19 amounts to 12,106. However, this lack of testing could be due to the underestimation of cases and increasing uncertainty [14].

3.3. SDG 4

The rate of school dropout in Ecuador in the last decade followed a regular decrease, reaching values of 3.8% (2010); 3.1%(2014), and 5.67% (2020) for the Highlands-Educational Regime [27] and the same tendency is seen in the entire country (Table 2). In a survey [28], it was found that 42% of dropouts were due to economic factors and 3% to a lack of internet connection. The Information and Communication Technology (ICT) indicators [29] showed that 74.7% of households do not have a desktop computer and 68.7% do not have a laptop, as shown in Table 2. Access to technology is still an obstacle for specific students; there are growing trends regarding school dropouts that affect the guarantee of inclusive, equitable, and quality education [30].

Table 2. Global data of Education and ICTs in Ecuador from 2015 to 2020.

Year	Students Enrolled *	Schools *	Teachers *	Schools as Internet Source (%) **	Households with Internet Access (%) **
2015	4,620,397	19,000	218,109	10.01	32.80
2016	4,574,350	17,000	214,478	10.79	36.03
2017	4,508,457	17,000	216,876	9.29	37.20
2018	4,465,240	17,000	219,406	7.21	37.17
2019	4,399,567	16,000	219,540	5.15	45.54
2020	4,307,554	16,000	206,448	0.47	53.21

Sources: * Ministerio de Educación [31], ** Peña M., A. and Herrera [29].

In addition, many schools were forced to close permanently due to the economic crisis (see Table 2) [32]. Nevertheless, the Ecuadorian government developed the COVID-19 Educational Plan, called Let Us Learn Together at Home, which contains pedagogical guidelines to follow while the health emergency lasts [33]. However, UNICEF considers virtual education a significant challenge [30]. Despite the decreasing number of teachers in the education system (see Table 2), teachers were provided with online courses for the development and improvement of digital skills in the context of virtual distance education by the Ministry of Education of Ecuador, who developed a self-learning course for teachers, called My Classroom Online (Mi Aula En Línea, in Spanish) [34].

3.4. SDG 8

According to the BCE, the GDP is the sum of the gross value added of all resident producers in the economy. Additionally, the GDP per capita is the gross domestic product divided by the population at the middle of the year. In 2016, Ecuador's GDP was affected by an earthquake and the drop in oil price [35], as shown in Table 3. However, the economy then recovered in 2017 due the increase in household final consumption expenditure and the general government final consumption expenditure and exports [36].

Table 3. GDP and GDP in growth rate in Ecuador.

Year	GDP(%)	GDP per Capita (%)
2015	0.10	−1.51
2016	−1.23	−2.90
2017	2.37	0.57
2018	1.29	−0.48
2019	0.05	−1.61

Source: Central Bank of Ecuador [12].

Furthermore, by the end of 2019, GDP decreased due to the lower dynamics of gross fixed capital formation and final consumption of the general government and the imports of goods and services [37]. At the end of 2020, the BCE declared a GDP of −7.8% due to the decrease in gross fixed capital formation, decrease in household final consumption expenditure, reduction in final consumption expenditure of the general government and contraction of exports of goods and services [38].

In March 2020, at least 70% of the productive sector ceased their activities. However, the Ministry of Labor reported that 425,328 people were found to be carrying out tele-work, and 138,927 in the private sector during the exception time in Ecuador. According to values from the INEC, of the total number of people with employment in December 2020, 51.1% of these worked in the informal sector. Likewise, during the pandemic, 180,852 contracts were terminated, of which 20% of the terminations occurred unexpectedly, leading to the unemployment of more than 30,000 people in the country [39].

As for equal pay, the INEC's latest report of the labor indicators of employment, unemployment and underemployment [40] stated that the average labor income of a man with a job was USD 309.9, while for a woman with a job it was USD 262.6.

Therefore, the first response measures to face the pandemic focused on alleviating financial and tax obligations, avoiding a deterioration in employment, and increasing access to credit. The development of regulations to allow new contracting modalities, the establishment of guidelines for teleworking due to the suspension of face-to-face work in both the public and private sectors, and the creation of the support program credit "Reactivate Ecuador" [41] were among the efforts to promote the resumption of productive activities. The Reactivate Ecuador program channels resources to the public and private financial system and the popular and solidarity economy sector [42].

4. Discussion

The ECE value, when positive, indicates effective control of the pandemic; when negative, the management is inefficient in control and mobility exceeds the reduction in ERR. In both cases, the value obtained for Ecuador was < 0, and, hence, was ineffective in the time frame analyzed. Furthermore, other countries faced the pandemic differently. The rapid widespread testing, diagnosis, tracing and monitoring by South Korea places it first in the ECE country chart (Figure 3). ECE values for OECD countries were taken from the 2020 Sustainable Development Report [6]. As for Brazil, Mexico, Peru, Colombia and Chile, some estimations were made following the same methodology employed for Ecuador and based on several academic publications from each country [7,10,43,44].

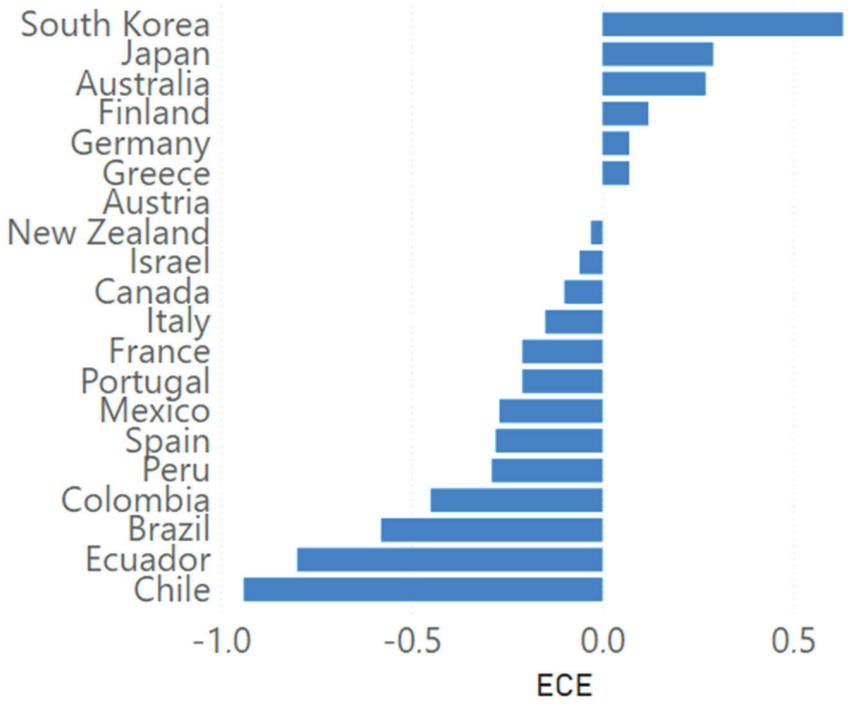

Figure 3. ECE per country.

4.1. Impacts on SDG 1

As a consequence of the lockdown and the interruption of productive activities due to the health emergency, along with a contraction of the economy, decreased the income of the population. The economic and social effect of unemployment are very pronounced in vulnerable sectors, particularly for people in extreme poverty who survive in the informal economy [45]. Poverty spreads due to unsatisfied basic needs and the worsening of the public's standard of living, especially in the most vulnerable rural sectors [45]. In 2020, the minimum income was 84.1 USD, 21% of a 400 USD wage to meet basic needs. Additionally, with a poverty rate of 32.4%, 3 out of 10 Ecuadorians live with less than 3 USD a day to meet their basic needs. As the relationship of employment and poverty are inversely proportionate [11], poverty and extreme poverty increased because the COVID-19 crisis

caused unemployment to rise. The COVID-19 pandemic directly affected organizations of all kinds and society in general, where families are made vulnerable by many necessary and mandatory restrictions that limit access to goods and services [45]. Although the law set on March 2020 promised money bonuses to poor people [39], the indicators of poverty did not decrease.

4.2. Impacts on SDG 3

Ecuador's geographical position makes it vulnerable to tropical endemic diseases, such as the vector-transmitted Chikungunya, Dengue and Malaria. Ecuador has been fighting a Dengue epidemic since 2018 [20]. Dengue has a seasonal behavior that aligns with the winter season in Ecuador [16,46], where the presence of dengue reservoirs is higher, therefore encouraging the spread of mosquitos. Dengue and COVID-19 present similar symptoms at the beginning of the disease, such as fever, chills, red skin and nausea [19–24]. A misdiagnosis of COVID-19 occurred in Thailand where a patient with an exanthema with fever initially diagnosed as dengue was eventually diagnosed for COVID-19 infection through a RT-PCR test [25]. Additionally, a co-infection of Dengue and COVID was confirmed in Reunion Island, suggesting that a co-infection might present more severe symptoms [47]. In Ecuador, where the incidence of Dengue and COVID-19 are both high, misdiagnosis can often occur. Therefore, it is recommended for Ecuador and countries with tropical climates and high cases of dengue to develop effective tests for both viruses and correctly diagnose each disease [20,24,25,47]. Ecuador does not have a good testing system. There were problems registering the actual number of infected people due the reliability of rapid tests [48]. Therefore, in comparison to the rest of the world's ability to control the pandemic (Figure 3), Ecuador shows poor management.

4.3. Impact on SDG 4

A global assessment of school closures due to COVID-19 carried out by UNESCO [49] showed that as of 20 April 2021, 202,366,403 students were affected worldwide, with 5,131,897 of these in Ecuador. The COVID-19 pandemic forced education to become virtual and according to the INEC's survey [29], more than 50% of households do not have access to a desktop computer or laptop, items that are crucial for virtual education [50]. Another important resource is internet access, which only 53.21% households have. Therefore, for students without a desktop computer or laptop, and without internet connection, their probability for learning is very low [50]. The change to virtual education caused the rate of enrollment of students in the period 2019–2020 to drop by approximately 3%. In addition to student enrollment, schools were closed permanently, and teachers were fired or quit their work (see Table 2).

4.4. Impacts on SDG 8

The International Labor Organization (ILO) established that the COVID-19 crisis will cause an increase in world unemployment between 5.3 million people and 24.7 million people [51]. The closure or the administrative adjustments of public and private organizations caused by the COVID-19 pandemic has left many Ecuadorians without a job. The quarantine did not allow people to work and interrupted their professional activities without advance planning, which directly affected the per capita family income [45]. The GDP measures the economic growth of a country; it is composed of public spending, private consumption, investment and net exports. GDP has an inversely proportional relationship with poverty; since 2018, GDP has decreased as poverty increases. The GDP per capita will rise unless the national income increases and populations remain constant [52]. Furthermore, the increase in unemployment, the slow recovery of the economy, the rise in external and internal debts, caused both GDPs to drop and affected the achievements of economic growth [53]. Despite measures made by the government to face the economic crisis, the capital money of the country is mostly devoted to the control of this current health emergency [54].

5. Conclusions

Data suggest that the country's response to the pandemic was ineffective, partly due to the country's circumstances before the pandemic, such as its weak health system and economy. The pandemic seems to have set back Ecuador's progress towards SDG 1 because the indicators of poverty and extreme poverty have increased. Regarding SDG 3, the increase in Dengue cases increases the likelihood of co-infection of both viruses and the delay of treatment for COVID-19 and decreases the efforts to fight the neglected Dengue disease. Limited SARS-CoV-2 tests for all regions of Ecuador has generated deficiencies due to problems regarding diagnosis and follow-up of possible COVID-19 infections, with rural areas being the most affected. Therefore, this assessment of the efficiency of epidemic control in Ecuador shows that managing and controlling mobility was not effective in the analyzed time frame. Education indicators have decreased due to the lack of ITC resources to attend to the new modality of virtual education, unemployment has increased due to the imposed economic measures on public and private organizations, and the increase in unemployment and poverty has affected GDP per capita and GDP. These indicators show that Ecuador's economic growth is decreasing due to the pandemic.

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Proceeding Paper

Resetting Tourism after COVID-19 with Particular Emphasis on South Asia †

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Abstract: Tourism is a significant contributor to the economy of some countries. There are multiple countries, especially in South Asia, whose economies are largely reliant on tourism. The World Tourism and Travel Council estimates that the tourism sector contributed USD 234 billion, or 6.6% of the region's GDP, in 2019 in South Asia. Countries such as Maldives and Mauritius have faced huge issues since the COVID-19 pandemic brought about a complete shutdown of their tourism industries. The revival of tourism is a must for these counties; otherwise, their post-pandemic economic recovery will be majorly affected. This paper analyzes the effect of COVID-19 on the tourism sector in South Asia and sets out solutions for rebuilding it. This paper elaborates on the solutions mentioned above by emphasizing certain aspects. Firstly, this paper recommends that governments use the general equilibrium model as suggested by the report of the United Nations Conference on Trade and Development (UNCTAD). The UNCTAD report concerns the effect of COVID-19 on tourism. The general equilibrium model can be used to assess the implications of COVID-19 on the tourism sector effectively. Using this model, countries can accurately evaluate the effects of the tourism shock on the economy. Particular attention should be placed on developing countries wherein social progress has faced issues by the fall of tourism revenues. This paper suggests using the South Asian Association of Regional Cooperation (SAARC) as a platform for setting up tourism bubbles to deal with this issue.

Keywords: tourism; South Asia; COVID-19; general equilibrium model

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1. Introduction

Tourism was one of the first sectors to be severely hit by the pandemic. Containment measures forced a near-complete halt to tourism activities worldwide. Additionally, the sector risks being one of the slowest to recover, given the continued travel restrictions and global recession. This has ramifications beyond the tourism economy, as numerous other industries that are reliant on tourism are also heavily harmed.

Numerous countries, particularly in South Asia, have economies that are heavily reliant on tourism. According to the World Tourism and Travel Council, tourism contributed USD 234 billion, or 6.6 per cent of South Asia's GDP, in 2019 [1]. These South Asian countries have faced significant challenges since the COVID-19 outbreak, forcing the closure of their tourism businesses. Tourism resurgence is critical for these counties; without it, their post-pandemic economic recovery will be significantly harmed.

This paper first recommends that governments use the general equilibrium model as suggested by the report of the United Nations Conference on Trade and Development (UNCTAD). The UNCTAD report concerns the effect of COVID-19 on tourism [2]. The general equilibrium model can be used to assess the implications of COVID-19 on the tourism sector effectively. Using this model, countries can accurately evaluate the effects of the tourism shock on the economy. Particular attention should be placed on developing countries wherein social progress has faced issues by the fall of tourism revenues. Secondly,

this paper examines the issue of post-travel quarantine requirements, which pose a hindrance to many tourists. This paper suggests using the South Asian Association of Regional Cooperation (SAARC) as a platform for setting up tourism bubbles to deal with this issue. A similar model to the New Zealand–Australia model of tourism bubbles is suggested. Multiple South Asian countries cannot use the same framework since the immigration systems differ, but inspiration can be sought from the New Zealand–Australia model.

2. Need for Using General Equilibrium Models

Historically, tourism researchers and policymakers have estimated the economic implications of changes in tourism expenditure using input–output (I–O) or social accounting matrix (SAM) models [3]. Regrettably, these models have several quite restricted assumptions, reducing the accuracy of their estimations.

Real-world demand and supply characteristics that affect the economic consequences of shocks to tourism expenditure can only be adequately captured using computable general equilibrium (CGE) models. The term computable refers to a model's ability to quantify the impacts of a shock to an economy based on underlying economic benchmark data/the representation of an economy. The term "general" refers to the fact that it encompasses various economic agents engaging concurrently. Equilibrium occurs in a CGE when all producers, consumers, employees, and investors are content with the quantities of products produced and consumed, the number of hours worked, the amount of money saved and invested, etc. [4].

CGE models, which have become a standard tool for policy analysis in a majority of sectors of the economy, are widely used by international organizations such as the World Bank, the World Trade Organization, the International Monetary Fund, the Organization for Economic Cooperation and Development, and the European Commission, as well as by government agencies, research centers, and consulting firms worldwide [5]. Moreover, CGE models can be built for policy analysis at a variety of spatial scales, including the country level, the regional level, the multiregional level, and the multinational level. This makes CGE models ideal for estimating the pandemic's impact on tourism.

3. Applying the General Equilibrium Model

CGE models are increasingly being used to research and formulate tourism policies. Several examples of topics covered include the economic consequences of changes in inbound tourism; the impact of tourism on income distribution and poverty reduction; the economic consequences of tourism crises; the economic consequences of climate change; the economic consequences of special events; and the evaluation of economic policy on tourism industries.

To operationalize a CGE model, the associated social accounting matrix (SAM) must be constructed, and estimates of critical behavioral factors affecting consumer demand, manufacturing technology, and the substitutability of imported and domestic products must be obtained. Calibration is the final phase.

CGE models shed light on the structural consequences of an increase in inbound tourism [6]. An increase in inbound tourism can result in improved overall growth in the real GDP, real exchange rates, real wages, the Consumer Price Index (CPI), and net benefits or welfare. The modeling demonstrates that some sectors benefit from tourism expansion while others suffer.

4. Case Studies

4.1. Australia

According to an Australian study, sectors that benefit from increased inbound tourism include service industries that directly serve international tourists and industries that indirectly supply tourism-related activities, while sectors that suffer include non-tourism exporters and industries that compete with imports [7].

4.2. Fiji

According to research conducted for Fiji, gains in tourism-related sectors are partially offset by losses in traditional export- and import-competing businesses, owing in part to a tourism-induced currency appreciation [8].

4.3. Singapore

CGE modeling indicates that inbound tourism makes a sizable contribution to the Singaporean economy, vying for resources with non-tourism industries [9]. In addition, inbound tourism contributes significantly to the appreciation of the Singapore dollar, which has a significant negative influence on the country's other exports. The results show that Singapore's data-driven marketing approach, which is aimed at increasing overall visitor expenditure, may not always maximize tourism's contribution to the GDP, employment, and household income. Studies confirm the results of CGE modeling in measuring the economy-wide effects of various tourism market sectors in comparison to the simple expenditure yield measurements used in many nations to drive destination marketing.

5. Role of the SAARC

The United Nations Economic and Social Commission for Asia and Pacific has proposed using tourism bubbles to help South Asian countries recover economically following the pandemic [10]. India has taken the lead on this endeavor by establishing an agreement with Sri Lanka on air bubbles [11]. Two countries enter into such an air bubble agreement by establishing a set of laws and restrictions and signing a bilateral deal allowing their airlines to fly international flights between them. The SAARC can serve as a good forum for bringing countries together to work on bilateral or multilateral air bubble agreements in this regard. The New Zealand–Australia travel bubble agreements provide inspiration. While SAARC countries' immigration procedures differ from those of Australia and New Zealand, they can serve as an example for SAARC countries. Collaboration between the National Tourism Authorities (NTAs) of the participating nations is critical for this strategy to operate. This can be facilitated further by the establishment of a COVID-19 Tourism Response Group under the auspices of the SAARC. This group will be in charge of coordinating between the NTAs and will be subdivided into subgroups under the auspices of each national government. The committee's duty would include developing standard operating procedures for tourism and coordinating with relevant law enforcement authorities. Additionally, a liaison would efficiently communicate any concerns and policy proposals to the government, as the tourism industry is clearly a stakeholder in the economy's recovery as a whole.

6. Conclusions

South Asia's revival of tourism appears to be best served by the utilization of tourism bubbles. However, before any solution can be implemented, it is necessary to quantify the pandemic's impact on the tourism industry. The CGE model appears to be the optimal choice for this calculation. The CGE model may be customized to calculate the economic damage caused by a hit to the tourism industry in any country, as it has done effectively in Australia, Singapore, and Fiji. The SAARC should serve as a platform for establishing tourism bubbles across South Asia. This will necessitate collaboration between SAARC countries and their respective NTAs. The SAARC can serve as a venue for facilitating the implementation of actions necessary to make these solutions a reality. South Asia is aware of the actions necessary to resurrect its tourism industry, but it will require stronger cooperation and for these countries to set aside their differences and work cooperatively. The question is whether they will do it.

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Proceeding Paper

How Design Thinking Helped Craftwomen to Solve a Plastic Pollution Problem †

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Abstract: In Morocco, the project was aimed at reducing plastic pollution and increasing the local craftwomen's income. Design thinking and Facebook were used to support craftswomen in the search for solutions. The research question was: What is the relevance of the craftswomen's solutions, when they are supported with design thinking and Facebook? A total of 37 evaluators analyzed the participants' prototypes with creativity criteria. The craftswomen created innovative manufacturing techniques: stuffing objects with plastic scraps, assembling compact discs to make decorations, etc. Several prototypes contributed to reduce the plastics thrown into the Sea. The adaptation criterion was given a good score. The criteria of novelty and originality were fairly reached. The elaboration criterion received a lower score.

Keywords: design thinking; sustainable development solutions; environmental education; plastic pollution

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1. Introduction

The Plastic-Free Surf Project took place in the Al Hoceima Park, Morocco. It aimed at reducing local plastic pollution and contributing to an increase in the income for the local population, especially rural women. The Al Hoceima National Park is located on the Mediterranean coast of Morocco, near the town of Al Hoceima. Thanks to its geomorphology and contiguity between the sea and the mountain, the Park is characterized by important terrestrial and marine biodiversity. In addition to many socio-economic issues, the Park also has a number of environmental problems. One of these problems is significant solid waste pollution, more particularly plastic waste, which negatively impacts both the quality of the natural landscape, as well as the continental and marine biodiversity. This plastic waste, discarded by the local population and visitors to the Park, is carried by flood waters directly into the sea, aggravating plastic pollution, an already very significant problem in the Mediterranean Sea.

Like other environmental problems, the problem of plastic waste is complex, with multiple impacts, causes, actors, and risks. It seems reasonable to think that removing plastics in a coastal community requires that residents understand the harmful effects of plastics on marine animals and, ultimately, their own health, not to mention the effect of plastics pollution on income-generating tourism activities. This paradigm shift is not easy for anyone, including the communities of Al Hoceima. Everywhere in the world, plastics are part of everyday life. Their ease of shaping, durability, and resistance to impact, temperature, humidity, and detergents, make them useful in a diversity of industries, such as packaging, construction, automotive, electrical, etc. Although new plastics, made from resins, plants, or milk are available around the world, these alternatives are not yet present

in the communities of Al Hoceima. Most residents in these communities use and discard plastic products regularly, mostly unaware that substitute products exist, such as, for example, reusable bags made of natural materials for shopping or metal and glass bottles to transport liquids. Reducing plastics and alternatives (not widely available in shops) are, therefore, not common practice within the local population. In addition, local waste collection systems are not designed to recycle garbage, making change in this regard rather difficult to implement. Finally, people in the communities of Al Hoceima seem to have developed a habit of throwing their plastic waste and other garbage directly into nature.

2. Materials and Methods

Faced with a variety of environmental problems, citizens from our study communities and throughout the world are looking for solutions to improve their living conditions. Sometimes, researchers accompany them during their quest for such solutions. What are key interventions for promoting effective support towards solutions among citizens? How are these interventions applicable and adapted to the needs of those affected? Several international organizations are currently using a creative problem-solving approach called design thinking to pedagogically assist social groups as they analyze local problems, propose and test solutions. Such organizations, including IDEO.org (in the United States), INDEX (in Denmark), Hasso Plattner Institute (in Germany), and Design for Change (in India), use design thinking to create products or experiences that improve the lives of communities.

Design thinking comes mainly from two pioneers: Tim Brown and David Kelley, founders of the IDEO design and innovation firm. It is a human-centered approach that relies on innovation, collaboration, and creativity to solve a multitude of social or environmental problems. Intuition matters in design thinking and there are typically numerous solutions, which are quickly produced through experimentation. Failure is valued and, above all, the needs of users are considered [1]. A creative and analytical approach, design thinking is an amalgam of concepts in engineering, design, arts, social sciences, and business. It is a collective intelligence approach that places people, their behaviors and needs at the center of a process of co-creativity involving frequent feedback from the solutions users.

Design thinking applies the designer's sensitivity and methods to solve complex problems. Indeed, designers are used to confronting complex problems by generating various solutions that they test in order to gradually improve them. In a rigorous process using well-defined tools, design thinking, sometimes divergent and sometimes convergent, uses both creative and analytical modes of reasoning [2]. Design thinking takes place according to a sequence of distinct, non-linear steps in which back-and-forth actions (iterations) intersect:

1. Observation-inspiration: an ethnographic survey is performed to understand the people's (the users) concerned around the problem and to empathize with their perspective on the situation.
2. Definition-synthesis: the problem is defined several times. Information and various perspectives related to the problem are researched. The information is synthesized to pose the conceptual challenge in a few statements.
3. Ideation: many ideas are generated and some are chosen.
4. Prototyping: prototypes are quickly constructed to illustrate the ideas chosen so as to share these ideas with users and to evaluate their potential.
5. Tests: prototypes are assessed by collecting the opinions of users and experts. The winning prototypes are refined.
6. Communication: the final solution is made public [1].

Generally, in design thinking, facilitators use traditional tools: post-its, whiteboards, role-play interactions, etc. However, today there are also collaborative digital tools (ICT) that could facilitate the co-creation of solutions during design thinking. Using these ICTs, the problem solvers could share information (Empathy Maps), synthesize information

(Popplet), propose and comment on ideas (Padlet), choose ideas (Loomio), draw prototypes (Tinkercad), plan (Wrike), and communicate (Facebook) [3]. The technological tools used in design thinking have, however, not been widely investigated. Used in conjunction with design thinking, collaborative digital tools (ICT) can facilitate the co-construction and the resolution of a problem. According to El Jai et al. [4], Facebook represents a relevant tool to complement design thinking, when problem solving. Though the solvers are not physically near each other, the sharing of opinions, information and solutions about a problem is still possible through ICT and, as such, the design thinking process can continue. Additionally, Facebook lets solvers express diverse opinions, making it easier to express a range of perspectives related to the problem [5].

Three intervention tools (one procedural tool and two collaborative digital tools) were chosen to support 10 craftswomen of the Al Hoceima Park, as they searched for solutions to a local plastic pollution problem, namely design thinking, Facebook and WhatsApp. The research question was expressed as follows: What is the relevance of the solutions proposed by the craftswomen to the problem of plastics, when they use a design thinking process and are supported in problem solving with Facebook and WhatsApp?

In Bades, an emblematic historical and natural site of the Rif region, in the Al Hoceima Park, Morocco, the participants in the «Plastic-Free Surf Project» were members of an artisanal cooperative. This cooperative works in the manufacture of knits, crocheted items, and products made from vegetable matter (alfa and saw palmetto). Representatives of this cooperative were contacted and they demonstrated a willingness to participate in the activities of the project. About 10 artisans participated and were accompanied by the research team for a total of 12 months, with the aim of reducing plastic objects discarded in the region, ultimately ending up in the Mediterranean Sea. The idea was also to allow these women to manufacture and sell new products that would help to reduce the plastic objects used locally, promoting reuse of these plastic objects. In face-to-face workshops and as part of a private Facebook group, the project followed the steps of design thinking as experienced by the participants: observation, synthesis, ideation, prototyping, testing, and communication.

Workshops were organized in November 2019 within the cooperative and participating members applied the stages of design thinking. Facebook and WhatsApp groups were also used for networking and to continue the design process while the women were away from the research team. During the first stage (observation-inspiration), a two-day workshop was held with participating women. They were invited to describe the waste problem in their region, to provide their opinion on this issue and to identify the sources of plastic pollution in Al Hoceima National Park. To enrich the discussion, images showing plastics accumulated in the sea and on beaches, as well as plastic waste collected in the field were made available to the participants. During the second step (synthesis), a Journey Map encouraged them to describe and draw the use of plastics from sunrise to sunset by various people in the region (themselves, farmers, fishermen, traders, hoteliers . . .) and by tourists. The women described how they use plastic bottles and bags, cosmetics, etc., in their daily lives. They expressed knowledge that plastics are ubiquitous and harmful. Indeed, pieces of plastic are often found in the stomach of animals they raise and in locally caught fish. To help the women come up with ideas for reusing plastics (ideation), images of replacement items were provided (biodegradable bags, sandwich cases, bamboo utensils, beeswax covers). Images showing products created with recycled plastic and microplastics were also shown (jewelry, paintings with relief in microplastics, decorative objects).

The following problem was then posed in collaboration with the participants: How could we reduce the quantity of plastics rejected from the village of Bades, while creating products that can be marketed by the cooperative? The challenge was to reuse existing plastic objects to make them useful again in a different way, ideally with an aesthetic added value. In principle, reuse solutions should be durable and useful, with an aesthetic added value. Another possibility was to reduce the use of plastic objects (bags, bottles), replacing them with alternative products. Through brainstorming, the women proposed

initial ideas for involving the cooperative in the reduction and/or valuation of plastics and microplastics. For example: painting pictures on which pieces of plastic would be stuck, making replacement products such as fabric bags, decorations, and jewelry.

The rest of the project took place mainly on the Facebook and WhatsApp groups created during this first workshop. In fact, from 2020, the COVID-19 pandemic prevented all planned trips by researchers to Bades. Over the next nine months, the prototyping and testing stages were experienced entirely on Facebook and WhatsApp, through daily exchanges. The artisans created hundreds of prototypes and posted them on private social media, receiving feedback from peers and researchers. Ideas for craft products from websites such as Pinterest were also exchanged. The craft products from Pinterest were not made from plastic, but the craftswomen tried to construct the same products from plastic samples cut from household products: bottles, bags, compact discs (CDs), etc. Interestingly, the initial prototypes gradually inspired completely new ideas. After six months, some prototypes, designed by the participants, lacked development and were difficult to market. However, after nine months, the researchers noticed new ideas and saw an improvement in the quality of the prototypes. It was then that 35 prototypes were selected to assess the impact of the design approach experienced on the local resolution of the plastics problem.

The research part of the project adopted a mixed method design, since the participants' prototypes were evaluated using both quantitative scores and qualitative comments. After nine months of work with prototypes, Canadian and Moroccan evaluators (n = 37 in total) from different arears of expertise (sciences, art, law, journalism, education) were invited to comment and score 35 prototypes. The researchers analyzed the participants' prototypes with the following creativity criteria, adapted from Demirkan and Hasirci [6]: environmental value, adaptation, novelty, originality, elaboration, and fluidity. These creativity criteria were applied in the project as such:

- Environmental value: product which helps to lower the quantity of plastics discharged into the Mediterranean Sea, in Bades.
- Adaptation: marketable product, likely to be purchased by tourists.
- Novelty: new product, never made by other craftsmen in Morocco.
- Originality: completely new idea of using or replacing plastic.
- Elaboration: aesthetic product, demonstrating fine workmanship and attention to detail.
- The fluidity criterion (large number of ideas) was used to evaluate the whole group of prototypes.

3. Results

The average score for all prototypes and for all criteria was 14.03 (out of a total possible score of 20). The prototype in Figure 1 had the highest score, while the prototype in Figure 2 had the lowest score. In addition, 19 products (out of 35) scored above-average and 16 products (out of 35) were rated below-average.

Figure 1. The prototype that received the best average score (for the five criteria).

Figure 2. The prototype that received the worse average score (for the five criteria).

On average, the environmental value of the products was judged to be quite good (3.00 out of 4). Indeed, the evaluators concluded that several prototypes, while not perfect, contributed to reduce the quantity of plastics discharged into the Mediterranean Sea, in Bades. The adaptation criterion (marketable product) was given an average score of 2.83 (out of 4), likely because the participants only started to adapt their products to tourists' taste and needs at the end of the project. As for novelty and originality, these criteria's respective scores were 2.71 and 2.76 (out of 4). Indeed, the craftswomen's prototypes demonstrated a particular level of ingenuity, since they produced new uses for a material that is often difficult to reuse. The participants carried out the construction of varied prototypes, also meeting the criterion of fluidity (large number of different ideas). Craftswomen made jewelry, home decorations, toys, fashion accessories using innovative manufacturing techniques, such as sticking microplastics on paintings, stuffing objects with plastic scraps and used bags, cutting compact discs to assemble them with fabrics, embroidering plastic jewelry covered with felt, etc. The elaboration criterion received a score of 2.73 (out of 4). Overall, the team's researchers believe that the craftswomen's prototypes still lack a certain aesthetics and attention to detail. During the Facebook exchanges, the researchers noticed that the participants were motivated and creative and constantly wanted to produce new solutions, without necessarily taking the time necessary to complete their work well.

Figures 3 and 4 show examples of prototypes that received high scores for «environmental value» and «elaboration».

Figure 5 shows an example of a prototype that received a medium score for originality (2.85, out of 4). Indeed, the participants had the idea of cutting plastic scraps with which they stuffed toys. The judges found the idea original but expressed concerns for the safety of children if these toys were to break.

Figure 3. A prototype that scored well for «environmental value» (3.51 out of 4).

Figure 4. A prototype that scored well for «elaboration» (3.32 out of 4).

Figure 5. A prototype that received a medium score for «originality» (2.85 out of 4).

Finally, Figure 6 shows an example of a prototype that received low scores for elaboration (2.27 out of 4) and adaptation (2.46 out of 4). Here, the reviewers found the idea of repairing an old plastic chair for reuse interesting. However, they felt that this product was not as aesthetically appealing and likely difficult to market.

Figure 6. A prototype that scored low for elaboration (2.27 out of 4) and adaptation (2.46 out of 4).

4. Discussion and Conclusions

Design thinking, complemented by Facebook and WhatsApp, along with the participating women's high level of motivation, seems to have led to the production of many

different prototypes, some of which quite promising in terms of the environment, commerce and craftsmanship. The conceptual challenge of creating marketable products that reduce the plastics discarded into the sea was partially met for the village of Bades. The fluidity aspect seems to have dominated the experience, but the environmental and aesthetic criteria could stand to be reworked.

The craftswomen's efforts to improve the plastic problem made them more environmentally conscious. They said they now reduced the plastics that their village discard into the sea. Periodically, they also organized community beach clean ups. These behaviors could reduce the amount of plastic present in the stomachs of fish and locally raised hens.

This experience shows that it is not easy to create aesthetic and marketable products from plastic scraps. Some products are not good enough to sell and others will end up in the trash after a quick use. For this region, replacing disposable plastic bottles and bags with more durable accessories will require widespread education, peer modelling, and well-targeted advertising. The manufacturing of new types of compostable and reusable plastic, made from plants for example, would also be of crucial importance.

Design thinking can create more fluidity in solutions. In sustainable development, design thinking could be complemented regularly by inviting problem solvers to reflect on the effects of environmental problems and on the solutions for local natural species [7]. The ambitious idea of "nature regeneration", newly popular during the COVID-19 pandemic, could be a source of inspiration. The solvers could be asked the following question: How could you regenerate both your business activity and the quality of life of local natural species?

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Informed Consent Statement: Informed consent was obtained from all persons involved in the survey implanted in this study.

Data Availability Statement: All data are available with the main author and can be accessed on request.

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How Difficult Is It to Build a Sustainable and Inclusive Company in the Global South? Reflections on a Case in Chocó (Colombia) †

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Abstract: Planeta is a community-based company located in Chocó (Colombia), a place marked by profound social, economic, and political contrasts. Planeta is developing a business model on the açai's and jagua's value chain that is sustainable and inclusive. This paper introduces central elements to its path and reflects on its learning and difficulties over time. It results from a joint reflection between researchers, community leaders, and professionals from organizations that support Planeta's relationship with the markets.

Keywords: sustainable business; bioeconomy; community-based companies; Global South; acai

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1. Introduction

How difficult is it to build a sustainable and inclusive in the Global South? This text reflects Planeta's (a community-based company located in Chocó, Colombia) experience developing a sustainable and inclusive business model. Planeta was founded in 2016 to generate job opportunities for local communities. It is located on collectively owned lands, based on community organization, strives for sustainable use of wild fruits, and seeks inclusive territorial development.

Planeta builds on the experience and lessons learned during a more than ten-year long prior corporate effort. Planeta's work revolves around invigorating açai's and jagua's value chain and selling natural foods and antioxidant-rich ingredients. It is located in Chocó (Colombia), one of the areas with the highest biodiversity per square meter in the world [1]; however, it is also home to one of the highest rates of habitat loss and ecosystem degradation. In addition, most of its population are black communities living in poverty, a third of which live in extreme poverty. Chocó is an area historically affected by Colombia's armed conflict and has dynamics characterized by extractive economies and environmental conflicts related to timber exploitation and illegal mining [2].

Planeta seeks to develop a scheme for sustainable use of wild resources that brings wealth to local communities. Its founders are sure that the model must step aside from traditional extractive models that have been historically developed in the area and do not entail real opportunities for the community. As a result of its participation in several processes that seek inclusive corporate growth, nowadays, local, national, and international organizations recognize the potential of Planeta's model.

Planeta has achieved development in infrastructure, procedures, technology, and an increase in sales. However, its sustainability over time is still a challenge. What factors explain its path? This paper introduces elements central to Planeta's experience and reflects on its learning and difficulties over time. It results from a joint reflection

between researchers, community leaders, and professionals from organizations that support Planeta's relationship with the markets.

2. Planeta's Origins and Business Activities

Planeta is a community-based corporate initiative created to generate job opportunities by dynamizing the açai productive chain (Euterpe Oleracea), Jagua (American Genipa), and selling antioxidant-rich foods. Planeta's headquarters are in Vigía del Fuerte (located in Antioquia, which is a part of biogeographic Chocó), a municipality with a population of 9903 in a surface area of 1801 km^2 (445,036 acres). Most of Vigía del Fuerte's population are black (91%) and indigenous communities (3%) [3]. The municipality can only be accessed by plane or through the Atrato river.

In 2016, ten men and women from Chocó and Antioquia's Atrato region founded Planeta as a for-profit company. This endeavor builds on the learnings from a ten-year-long experience called Bosque Húmedo Biodiverso (BHD) (Biodiverse Rainforest), which worked as a for-profit community company. BHD was a joint initiative with investors, non-governmental organizations, and two companies from neighboring regions that would act as commercial allies to purchase jagua and açai fruit. This experience left two main learnings. First, it is possible to develop an entrepreneurial response commercializing ancestral and wild fruits while bringing new sources of income to collectively owned territories. Second, commercial agreements need to be transparent and equitable on several fronts: (i) price definition; (ii) acknowledgment of the contributions made by each of the actors; and (iii) distribution of economic benefits resulting from joint work.

Planeta oversees the harvest, transformation, and commercialization of açai. This effort has built a series of relationships with three main actors: (i) Cocomacia, (ii) local Community and Indigenous Councils, and (iii) families from the community. These relationships stem from an operational model that addresses procedural and logistic matters.

The Senior Community Council of the Integral Peasant Organization in the Atrato (Consejo Comunitario Mayor de la Asociación Campesina Integral del Atrato or Cocomacia) and the indigenous Councils, respectively, have the authority over and manage the territory, strive to protect its sustainability, and strengthen environmental and social processes. They are responsible for obtaining the permits for the use of resources. Local Community Councils and Indigenous communities develop organizational processes in each of the communities; they authorize the use of açai and receive a percentage of the profit of the fruit and palmettos sold on family and communal land. Land-owning families accompany the harvest. Under this scheme, Planeta is responsible for leading the harvest, following up on the permits for use, providing training in collection and management plans, purchasing the fruit from the communities, processing it under the INVIMA'S sanitary regulations, and selling it to the market, ensuring that all benefits go to the community.

This operation occurs in the Atrato region, a distant, dispersed territory connected only by the river with explicit social and economic inequalities. By 2018, 71% of the population at Vigía del Fuerte lived in multidimensional poverty conditions [1]; 25% of the population was illiterate; 50% was at severe risk of food insecurity [4]. Furthermore, 64% of the people in the area suffer from long-term unemployment, while 82% have informal work [5]. Additionally, the armed conflict has historically affected the site and serves as the turf for illicit economic activities that generate significant profits.

The context in which Planeta operates entails different challenges that raise its operation cost and urge the development of combined strategies. The company has been organizing the offer for açai and preserved palmettos with a system that allows sustainability while connecting with the market. In addition, Planeta has participated in several projects fostered by nongovernmental, national, and international organizations dedicated to supporting community-business endeavors. As a result, the company has consolidated commercial relations that align with its offer, the competition context, and operational capacity. Planeta currently has commercial relationships with national companies that understand the peculiarities of undertaking business amid the conditions in Vigía del

Fuerte. It continues strengthening its business model, stabilizing its production and commercialization, and creating the necessary alliances to fully develop the potential of this type of business in biogeographic Chocó.

3. Journey and Learnings

Planeta is the response of the local population to the paradoxical situation of inhabiting one of the richest rainforests in the world while living in poverty. It is a business community built on a logic of inclusive territorial development. Although it is a company under consolidation with infrastructure and organizational development, it still faces sustainability challenges.

Below are four reflections stemming from Planeta's direct experience; they concern the company's primary factors and apply to other companies trying to grow in contexts such as that of Vigía del Fuerte. These reflections are aligned with the moments in the production process.

3.1. The Conditions for Supplying Raw Material

Planeta's work with the açai pulp and preserved palmettos encompasses biodiversity's use and sustainable exploitation. This process entails complying with environmental rules to protect the rainforest; these rules do not apply to other crops.

Complying with these environmental regulations involves several challenges. On the one hand, compulsory requirements under environmental regulations to formulate management plans and obtain exploitation permits are expensive; the figures can be close to USD 22,500. On the other hand, the required procedures are similar to the compulsory requirements enforced in the rest of the country, even though the area is somewhat different; processing these requirements entails having access to technical knowledge, electrical power, and the Internet. This need is particularly problematic in a territory such as Vigía del Fuerte, where 71% of the population lives in poverty and there is no permanent electric power supply. The illiteracy rate is 25%, a figure far higher than the 5% illiteracy rate in Medellín—the closest capital city [3].

This way of regulating rainforest resources has two potential consequences. First, it allows only certain actors with the economic power and capacity to fulfill the regulatory processes to access a legal permit to use the forest sustainably. Many of these actors are companies from other regions of the country that fail to generate development processes within the territory. Second, this type of regulation does not bring incentives or the conditions necessary for communities to develop forestry activities legally. In a context where other illegal and more profitable economic activities—such as timber extraction— expensive legal processes are problematic and do not foster legality or care for the rainforest.

3.2. Market Conditions

Açai produced by Planeta has evident social and environmental attributes. It is produced by a community company seeking to generate job opportunities for local communities under a sustainable model that limits the amount of fruit extracted. However, obtaining this açai is more expensive than others produced under different territorial and environmental conditions. This system—combining tree growing with livestock production—is more costly than açai produced by national companies with better economic situations and farming massively.

In Planeta's experience, the national açai market is unwilling to pay extra for açai that has social and environmental attributes. Thus, the market's decision to purchase (or not) is essentially related to price and not to the product's social and environmental features. This forces Planeta to seek international markets that are more interested and willing to pay the additional cost for sustainable use of açai.

Accessing these international markets is a challenge. On the one hand, it requires obtaining quality certifications entailing deep internal transformations and vast investments. On the other hand, once the certifications are in place, the costs of moving a product from

Vigía del Fuerte to somewhere in Europe are high. Moving a product to Europe entails transportation in small vessels by the river to the capital city, then on land, and finally to a marine port.

3.3. Operational and Organizational Structure

Planeta is a company harvesting and transforming açai. Arriving at a standardized product that meets the quality standards set by national and international clients requires an organized and efficient productive structure. Attaining this structure requires developing organized processes, incorporating technical knowledge, and consolidating management processes that enable profitable management.

Combining these elements concerning the operational and organizational structure has been challenging in this context. One of these reasons is the inadequate infrastructure and lack of university education in the area. The municipality does not have any university; the closest one is 103 km away in Quibdó (Chocó's capital), and the second is in Carepa (in the Antioquia department), 132 km away. These universities do not offer programs related to Planeta's production needs; the academic offer is limited to education programs and a few engineering programs focused on transforming raw materials. In addition, the high illiteracy and school dropout rates mean the number of professionals in the area is low. Attracting professionals from other territories is also arduous since the social and economic conditions in the area are not attractive for young professionals in this or other regions.

On the other hand, neither Vigía del Fuerte nor Biogeographic Chocó, in general, have a well-developed network of actors supporting business development. According to the Departmental Competitivity Index, which measures different aspects that affect the level of competitivity in Colombia's department, Chocó's corporate dynamics in 2020 placed 29 out of 33; the participation of medium and large-sized companies placed 30 of 33. This lack of corporate fabric has implications for the local population's corporate culture. They have neither the experience nor the guidance in business management to consolidate and grow a company, neither the experience to manage conflicts when a single individual is both a shareholder and an employee, nor how to combine and balance business decisions when considering social and environmental matters.

Another factor that affects the operational and organizational structure is the lack of working capital, which the economic conditions in the territory can explain. Although nongovernmental organizations (both national and international) are unfolding several development endeavors to bring financial resources to the place, their operation usually falls into the hands of foreign actors in the area. These projects become sources of income and investment for local companies lacking working capital, yet they create several challenges. On the one hand, they are diverse and numerous, which distracts the attention and energy of community companies that must comply with different financing agencies' requirements and working logic. On the other hand, they place many interests and rationales at risk, thus creating tension for the communities, which are often the actors with the least negotiating power. Moreover, many of these development initiatives are conceived in the Global North, disregarding local communities' reality, dynamics, and aspirations.

4. Conclusions

This essay includes reflections on the aspects challenging the intention to build community-based companies in complex areas with contradictory tendencies, such as Vigía del Fuerte in Chocó. Planeta's experience exhibits the multiple structural and historical aspects surrounding these companies and illustrates the difficulties companies face in their effort to generate inclusive development. While these challenges respond to historical processes in the country, these aspects influence the conditions for the success of inclusive companies based in the Global South. Facing these challenges requires individual action from the communities and organizations working for development in these places; acknowledging them is thus paramount to finding more appropriate ways of supporting

them to build pathways to develop alternatives that bring tangible benefits to the people from the community.

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Proceeding Paper

Constructing Sustainable Shelters to Safeguard Monuments from Climate Change †

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† Presented at the ICSD 2021: 9th International Conference on Sustainable Development, Virtual, 20–21 September 2021.

Abstract: Aiming to address climate change, management plans for monuments and archaeological sites should be upgraded in order to increase the resilience of historical sites. Adaptation to the SDG 11.4 and SDG 13 (Sustainable Development Goals 11.4 and 13) is necessary to mitigate climate change impacts on heritage structures. Proper protection against climate change may be achieved by adjusting the microclimatic conditions of the archaeological site by using shelters that perform as regulators. Artificially created environments depend on the construction of shelters that will be capable of performing as intermediate barriers between the outer climate and the interior, having different temperature and humidity conditions. The shelter determines the interior climate and also interacts with the surrounding environment.

Keywords: climate change; built heritage; resilience; sustainability; management plan; protective sustainable shelters; SDG 11; SDG 13

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1. Introduction

In order for the Sustainable Development Goals (SDGs) to be achieved, scientific research should provide the knowledge required for designing, implementing and monitoring the SDGs, but it should also, at a practical level, provide standards and solutions [1].

Proper protection of heritage structures against climate change may be achieved by adjusting the microclimatic conditions on the site by using shelters, which perform as regulators. Artificially created environments depend on the construction of proper shells.

Since the shelter determines the interior climate and also interacts with the surrounding environment, it is crucial to define what we want to protect (type of findings and materials), whether or not human presence will be on the site, and take into account the climate and the morphology of the surrounding area.

Considering the protective shelter, recommendations should be given according to the size required, the architectural concept and shape to be integrated in the landscape, and the properties of the construction materials. An important issue is how to achieve energy efficiency, the cost of the construction and the possible funding sources. New challenges, such as energy autonomy, renewable systems, smart systems and Information and Communications Technology (ICT), have to be addressed.

Aiming at evaluating the construction of shelters in archaeological sites as well as their contribution to a stable microclimate on the site, the present paper includes comparative diagrams of temperature and humidity in underground heritage structures and proposes a methodology that can be used in similar cases [2]. In addition, this paper defines criteria and specifications regarding the construction of shelters for monuments and archaeological sites.

With respect to the SDGs, this work is at the nexus between SDG 11.4 and SDG 13. The target SDG 11.4 has a more prominent place as it aims to "strengthen efforts to protect and safeguard the world's cultural and natural heritage", while the target SDG 13 aims to "take urgent action to combat climate change and its impacts".

2. Built Heritage and the Concept of Sustainability and Climate Change Adaptation

Sustainability in tangible heritage can be described as the action of preserving heritage assets as adequately as possible, while at the same time providing the best possible access to the site, given limited resources. The National Park Service (NPS) Climate Change Response Strategy sets out four primary pillars for the management of protected areas: science, adaptation, mitigation and communication [3]. In this scheme, the science pillar collects all work undertaken to gather climate-relevant data (i.e., measurements, modeling and related techniques). Adaptation combines efforts to determine what to do about climate change, including policy, guidance and approaches to planning and decision making. Mitigation refers to efforts aiming at reducing greenhouse gas emissions [4].

Regarding adaptation, it should be mentioned that there are two types of it. First, there is adaptation of management approaches to address the impacts of climate change in cultural heritage. Additionally, there is learning from cultural heritage in order to assist in adapting resource management and society to climate change.

Strategies need to be developed in order to reduce the negative consequences of climate change in sites of historical value and also to mitigate climate change by reducing greenhouse gas (GHG) emissions. The tangible cultural heritage is threatened by the gradually shifting of weather patterns and by extreme events. An increase in temperature, together with changes in precipitation, relative humidity and wind, can negatively impact the materials comprising a built heritage. This takes place because a change in average climatic conditions as well as changes in the frequency and intensity of severe weather events can affect the biological, chemical and physical mechanisms, leading to the degradation of the heritage structures [5].

Sabbioni et al. [4] developed guidelines for adapting the European cultural heritage to climate change impacts; these guidelines were later adopted by the Italian Strategic Agenda. Those included strategies for both physical adaptation and adjusting management practices. Cassar [6] investigated the impacts of climate change in archaeological sites and suggested adopting solutions that are sensibly designed to the specific conditions of the site after a long-term program of monitoring and maintenance. Additionally, Cassar [7] summarized the adaptation measures suggested by the UN Educational, Scientific and Cultural Organization (UNESCO) and by the International Council on Monuments and Sites (ICOMOS), who recommend increasing research, knowledge, education and engagement and also the upgrading of management plans including risk assessments and monitoring procedures to increase the resilience of the sites.

Climate change adaptation is thus a relatively new challenge, and this is the case in particular in the field of cultural heritage.

3. Why Is a Sustainable Shelter Important?

In the case of underground heritage structures, the external structural components, especially the external layers which often support wall paintings, are the most vulnerable to cyclic changes of the microclimatic conditions. The hygrothermal behavior of the walls depends on the boundary conditions of temperature and relative humidity inside the chamber and in the protective shelter. The water content in the mass changes during the year. Moisture fluxes change from negative to positive during the spring, and they switch again to negative during the fall. Positive fluxes mean that water is moving from the inside to the outer facades and evaporating, causing exfoliation of the external plaster. Negative fluxes mean that water is moving from the exterior layers to the interior of the chamber, which is getting wet again. Thus, an annual deterioration cycle is taking place.

Therefore, by stabilizing the conditions in the shelter, water movement is no longer taking place, and an equilibrium in the walls is achieved.

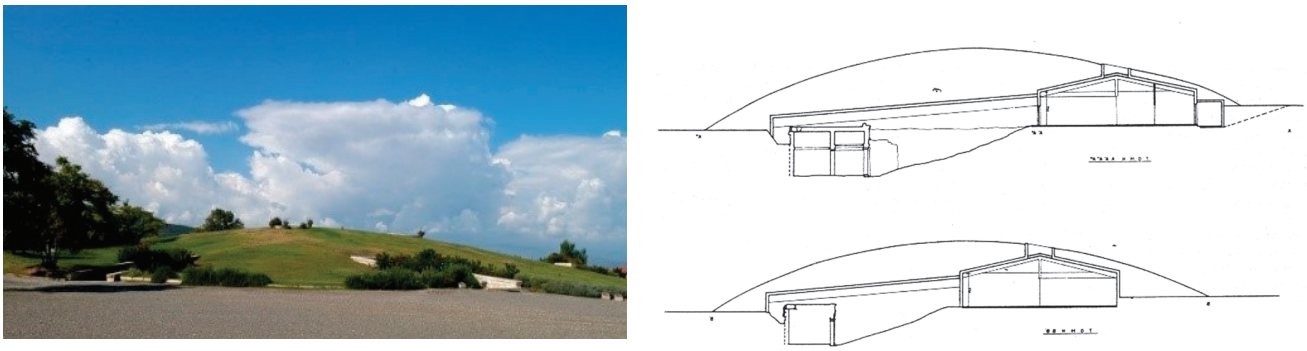
4. Shelters for Underground Heritage Structures. Case Studies Worldwide

Ancient tombs are underground structures, and as such they need specific protection measures on the site during the excavation procedure. They mainly need a proper shelter that will operate as a regulator for the microclimate.

Case studies worldwide show that the main issue to address when constructing shelters on the site is the stabilization of the temperature and humidity, thus reducing and minimizing the fluctuations of the exterior climate [8].

4.1. Royal Macedonian Tombs in Vergina-Greece

A tumulus-shaped shelter with a soil embankment was constructed over the Royal Macedonian Tombs in Vergina, including mechanical equipment to regulate the interior conditions of temperature and relative humidity (Figure 1, [9,10]).



(**a**) (**b**)

Figure 1. The shelter over the tombs in Vergina. (**a**) External view; (**b**) Drawings of the tumulus-shaped shelter.

4.2. Etruscan Tombs. Tarquinia and Cerveteri, Italy

In Tarquinia, Etruscan tombs dated from the 7th to the 2nd century B.C. were found, all carved out of bedrock. Problems of humidity were addressed. Once frescoes were repaired, transparent barriers, low-heat lighting and climatic monitoring systems were installed (Figure 2, [11,12]).

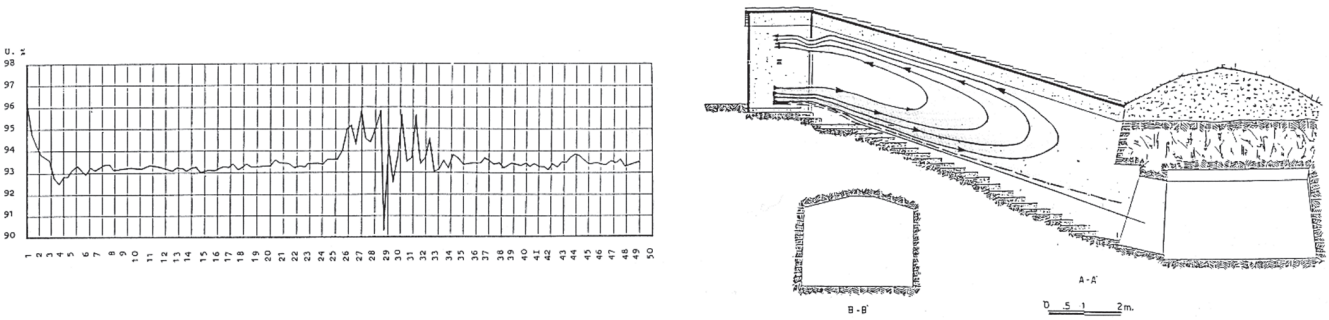
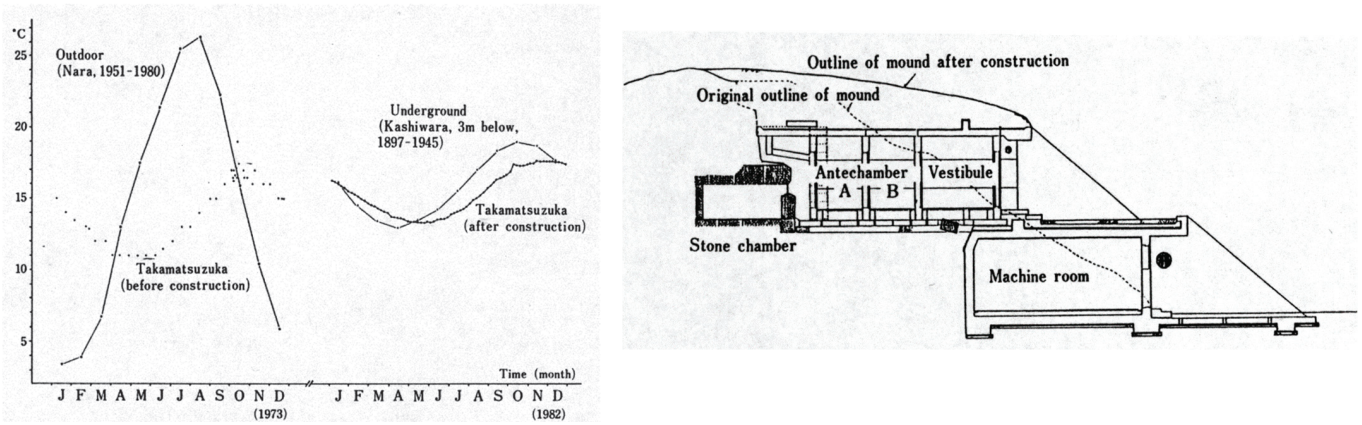


Figure 2. Tombs in Tarquinia. Cross section of the tomb Dei Giocolieri and diagram of the microclimate.

4.3. Tombs of the Emperors in Japan

The Takamatsuzuka tumulus, in the Asuka Historical National Park, is a site with great historic value, and its murals are considered to be national treasures. The burial is a stone chamber. Murals are painted on the walls and on the ceiling. The microclimate

is being controlled. The original murals are not available for public viewing; replicas are displayed in the Takarazuka Mural Hall next to the burial tumulus (Figure 3, [13–15]).

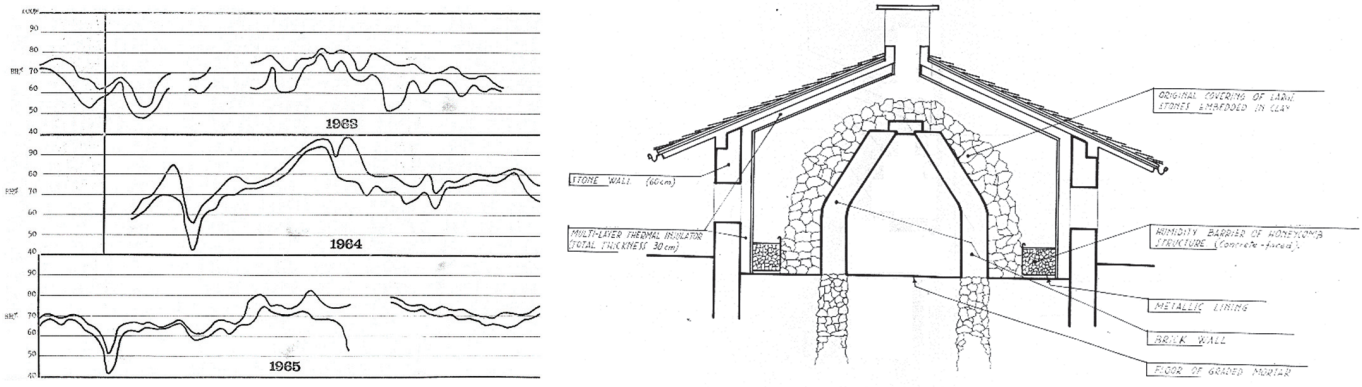


(**a**) (**b**)

Figure 3. The Takamatsuzuka tomb. (**a**) Annual changes in temperature inside the stone chamber of the Takamatsuzuka tumulus, before the construction of the preservation facilities (1973) and after the construction (1982); (**b**) Longitudinal sections of the preservation facilities.

4.4. Thracian Tombs in Bulgaria

The tomb in Kazanluk dates to around the end of the 4th century B.C., and it was inscribed in the World Heritage List. The burial chamber is decorated with murals. The tomb was secured under a permanent protective building with air conditioning to ensure a stable temperature. The negative impact of visitors is limited by constructing a nearby museum that contains a copy of the tomb and its decoration (Figure 4, [16]).

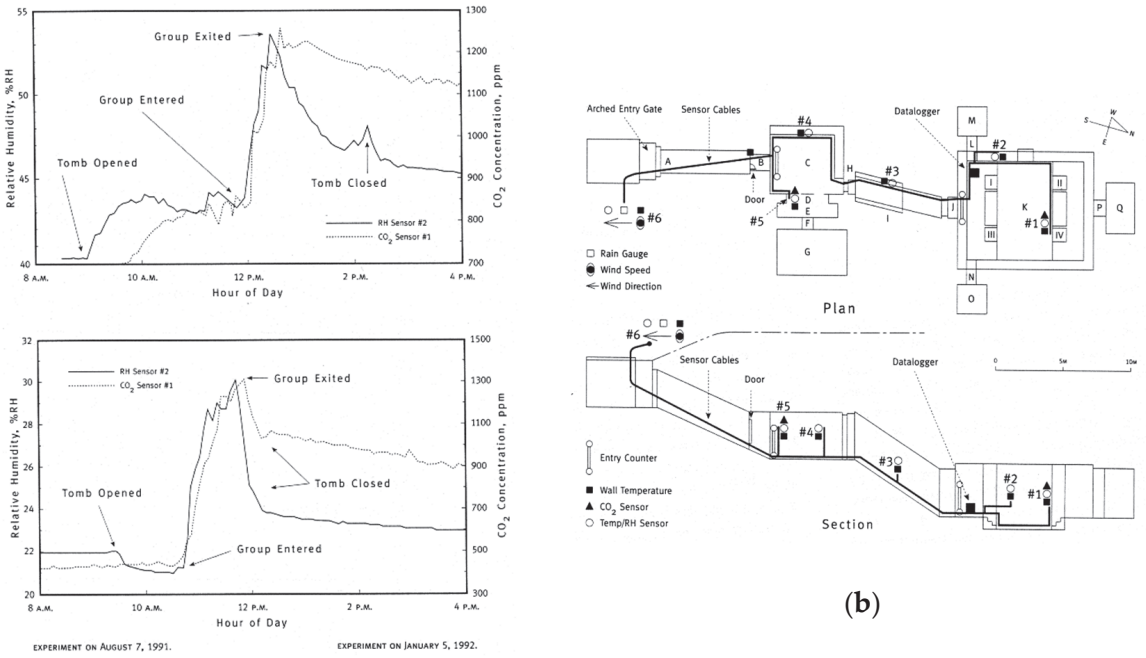


(**a**) (**b**)

Figure 4. The Thracian tomb of Kazanluk. (**a**) Fluctuations of temperature, before the construction of the shelter and after; (**b**) The tomb chamber and the protective shelter.

4.5. The Tombs of Egypt. Valley of the Kings and Queens

The tomb of Queen Nefertari, the favorite wife of King Ramses II (13th century B.C.), was discovered in the Valley of the Queens in 1904. In 1986, the Getty Conservation Institute in collaboration with the Egyptian Antiquities Organization created a multidisciplinary international group of experts who conducted an intensive six-year campaign. The works included microclimate conditions' assessment, analysis, emergency treatment and conservation of the extraordinary wall paintings (Figure 5, [17,18]).



(**a**) (**b**)

Figure 5. The tomb of Queen Nefertari. (**a**) Fluctuations of the temperature; (**b**) Longitudinal sections of the preservation facilities constructed on the site.

5. Evaluation Methodology

An evaluation methodology based on a computer simulation for a hygrothermal analysis will be crucial for decision making. In particular, a full understanding of the monument's hydrothermal behavior and the contribution of each individual factor to the deterioration processes are given by the simulation program. In this way, decision making for the strategic management and control of the microclimate in the shelter will be based on the results of the evaluation.

Through the data collection, analysis, simulation and interpretation of the results, research aiming at protecting Macedonian tombs has provided an assessment methodology for microclimate control strategies.

This methodology has the following steps [2,19–21]:

- Investigation of the microclimatic conditions with recordings using digital recorders with sensors, evaluation of the recordings and conclusions;
- Simulation in the computer and visualization of the deterioration processes using the simulation program WUFI©, based on the recordings. The simulation program provides data concerning the hygrothermal performance of the tombs' structural elements;
- Assessment of strategies to control the microclimate. As input, there are used set-points for the museum microclimate proposed by the international guidelines and standards;
- The interpretation of the results leads to conclusions about the effect of the applied microclimate on the hygrothermal performance of the tomb and, consequently, on the resulting deterioration processes;
- The general principles that come out can be applied to similar monuments.

6. Results Concerning the Construction of the Shelters of Macedonian Tombs

The variations of temperature and relative humidity have been recorded for three years inside three Macedonian tombs, two of them having been excavated in the area of Pella and the other near the village Agios Athanasios. After the excavation, protection shelters were constructed on the site, as follows:

The construction of a closed shelter on the Macedonian tomb of Agios Athanasios aimed at reducing the air exchange with the environment. It did not fully protect due to the lack of thermal insulation. The addition of styrofoam plates has improved the insulation inside the shelter.

The construction of an open metal roof on the two tombs of Pella was mainly intended to enhance the aesthetics of the monument, without contributing to the protection from the external climate (Figure 6, [2]).

(**a**) (**b**)

Figure 6. Open shelters in Pella. (**a**) Macedonian tumulus D′; (**b**) Macedonian tumulus C′.

The annual records of temperature and relative humidity show the following:

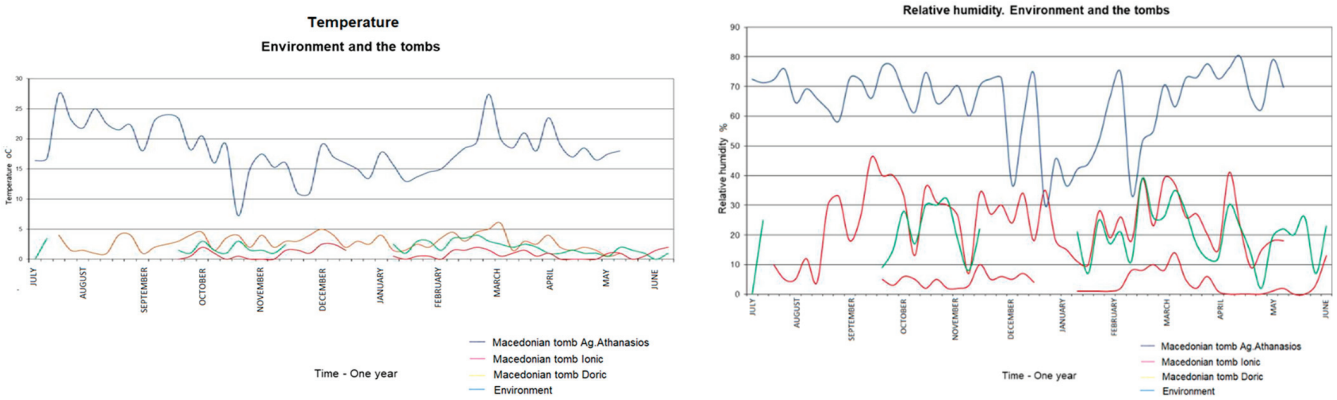
- The closed shelter of the tomb of Agios Athanasios seems to have protected the ancient structure to a certain degree. After its construction, the interior microclimate fluctuations were reduced but still remained quite intense. A wooden protective enclosure with a sheet of nylon was constructed. This was later reinforced with a double inlet and foam insulation, with noticeable results in reducing the range of fluctuations;
- The fluctuations were intense in the Ionic tomb C′, since no substantial intervention was made in order to reduce the effect of external climate changes, except for a sheet of nylon on the facade. The open metal shelter made no contribution;
- The fluctuations in the Doric tomb D′ were considerably reduced, as the closed shelter (a wooden enclosure with a sheet of nylon) has positively performed to isolate the interior from the outer environment and remained for a long time after the construction of the open metallic shelter.

The daily records of the contribution of the shelters to the interior microclimate show the following:

- Fluctuations in the external environment have been reduced in the tomb chambers. The shelter did not achieve the stabilization of the internal conditions, but only the minimization of the daily fluctuations;
- The shelter eliminated periodic fluctuations on a daily basis, but not on a weekly basis;
- Absolute moisture values were reduced internally, relatively to the environment;
- Fluctuations were caused by the entrance of people during the working hours of the day.

We must note that the reduction of the range of fluctuations inside depends additionally on the visitation hours and number of visitors, the dimensions and the volume of the

interior chamber, the size of the tumulus, the degree of the excavation and the exposure of the structural body to the environment (Figure 7, [2]).



(**a**) (**b**)

Figure 7. Comparison between the three tombs and the environment. Diagrams of the temperature and relative humidity during a year, showing the annual fluctuations inside the three tombs and the environment. (**a**) Temperature; (**b**) Relative humidity.

7. In Search for the Best Solution—Recommendations

The managerial and decisional adaptations to climate change suggested by the Intergovernmental Panel on Climate Change (IPPC) [22] included the following:

- Knowledge of climate change impacts on cultural heritage;
- Dissemination of information;
- Engagement with stakeholders (e.g., communities and decision-makers);
- Monitoring and maintenance;
- Inclusion of climate change in management plans;
- Preservation of values;
- Regulations and guidelines for adaptation;
- Mitigation strategies;
- Financial resources.

The IPPC also suggested practical adaptations, which included the following:

- Avoiding the inappropriate use of certain building materials and developing new materials compatible with the historic environment;
- Improving or strengthening monitoring;
- Digital recording of cultural heritage.

7.1. Minimum Requirements That the Shelter Must Provide

The shelter must provide the following minimum requirements [23]:

- Thermal insulation;
- Protection from overheating in the summer;
- Thermal capacity of the material of the components;
- Resistance to water vapor diffusion;
- Protection from external noise;
- Fire safety (non-flammable materials);
- Expansion properties control, thermal conductivity and water vapor permeability.

From a construction point of view, all of the above conditions are more easily met by an outer shell consisting of two layers. The exterior layer protects against rain, sun and winds, while the interior protects against heat and moisture. Possible air moisture can be treated with a slight ventilation of the space between the two layers of the wall. Such a construction solution also favors sound insulation.

7.2. Recommended Actions to Control the Microclimate

The following actions are recommended [24]:

- A shelter must ensure the control of microclimate conditions and possibly their correct setting to provide protection from humidity, temperature, solar radiation, micro-organisms, dust, atmospheric pollution, protection from indirect threats, i.e., those that act at an unseen level but are perceived only by their effects;
- Thermal insulation in the shelter is needed to protect the enclosure from overheating in the summer and frost in the winter;
- A sufficient heat capacity of the shelter components to avoid condensation and water formation internally during winter nights and to delay the temperature rise during peak hours;
- The possibility of receiving and removing the moisture generated in the interior (resistance to water vapor diffusion, water vapor barrier, dehydration);
- Double entrance to the shelter, so that one door will be closed when the other opens, in order to minimize the air exchange;
- In the case of mechanical systems operating in order to regulate the variations of temperature and relative humidity, energy consumption should be taken into account. Additionally, constant maintenance and good functioning must be ensured. The type of the shelter predetermines to a significant extent the internal climate and the cost of support systems;
- A mechanical system will manage the temperature and humidity in the shelter. Even if it cannot achieve a constant temperature and relative humidity throughout the year, it could minimize the heat and water flows through the tomb's walls;
- The energy consumption for maintaining a stable indoor climate can also be affected by interventions in the surrounding area which can modify the microclimate, using artificial barriers and proper plantations for shading and for changing the direction and speed of the winds [2].

8. Conclusions

This paper emphasizes the need for more research, identification and dissemination of practical solutions and tools for the incorporation of climate change adaptation in the preservation and management of cultural heritage. With reference to the SDGs, this work connects SDG 11.4 and SDG 13, as was analyzed in Section 2.

Management plans for monuments and archaeological sites should be upgraded in order to increase the resilience of historical sites. This research provides standards and solutions in a practical way, in order for the Sustainable Development Goals (SDGs) to be achieved.

There is a great difficulty in generalizing adaptation solutions due to the diversity of typologies of built heritage, the different geographical locations of heritage sites, the surrounding context in which they are located and the local climatic conditions to which they are exposed, as well as the state of decay and the different materials, geometries, and ageing of the heritage structures.

In the case of the Macedonian tombs presented in this paper, the assessment methodology that is proposed and the obtained results reveal the importance of applying simulation tools, which can capture the particularities of the microclimate and improve the accuracy of the performance simulations' results.

Climate change adaptation requires a case-by-case approach. Nevertheless, there are some types of adaptation practices that can be generalized, such as, for example, strengthening monitoring, using assessment methodologies based on simulation tools, protecting archaeological sites by constructing sustainable shelters in situ and of course increasing awareness of climate change impacts.

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A Theory of Change for Food Rescue and Distribution in Milan during the COVID-19 Emergency—A CSR initiative for a Bioplastic Manufacturer †

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† Presented at the ICSD 2021: 9th International Conference on Sustainable Development, Virtual, 20–21 September 2021.

Abstract: A corporate social responsibility initiative has been proposed as a development plan by CPB-Usobio srl, an Italian bioplastic packaging manufacturer active in the food industry. The project aims to launch a food rescue initiative to increase food security and reduce food waste in Milan. Similarly, it focuses on building community solidarity through inclusiveness and partnerships. The plan is expected to fight food insecurity of the vulnerable members in the community (SDG 1: end poverty); match the food supply excess with the demand for food of the poor (SDG 2: zero hunger); and make the city more inclusive by involving the community and creating partnerships (SDG 11: make city inclusive).

Keywords: food rescue; food surplus; food waste; sustainable waste; hunger; urban poverty; COVID-19; corporate social responsibility; partnerships; SDGs

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1. Introduction

A development plan was introduced as a strategy to launch a corporate social responsibility initiative in the Milan metropolitan area by CPB-Usobio Srl, an Italian bioplastic packaging manufacturer active in the food industry. The plan addresses the following objectives:

1. Launch a food initiative to fight against food waste.
2. Increase food security through food surplus redistribution.
3. Build community solidarity through inclusiveness.

As part of the project, a network of volunteers will be established to collect fresh food surpluses from local supply partners for distribution to people in need within the community using bioplastic containers. As an outcome of the project, volunteers will help fight against food waste and food insecurity while promoting bioplastic products throughout the food rescue and food distribution activities.

2. CSR's Sponsoring Organization and the Bioplastic Market

Componenti Plastici Biodegradabili srl (CPB) is a registered limited company, based in Trento (legal HQ in the Trentino region) and in Bergamo (production facility—Lombardy region), Italy, near Milan. Through its trademark, Usobio, the company offers a selection of compostable tableware, food containers and other packaging products made from 100% renewable resources [1]. The company's mission is to reduce the carbon footprint by promoting alternatives to plastic and supporting a sustainable food supply chain. Under this framework, the company intends to identify and invest in a corporate social responsibility initiative with a social and environmental impact on the local communities, thus becoming a social entrepreneur.

3. Milan Metropolitan Community: COVID-19 and Poverty

The initiative has been designed to be deployed in the Milan metropolitan area as a corporate social responsibility (CSR) initiative required by CPB-Usobio. The community of the Milan metropolitan area was chosen by CPB-Usobio as target for the CSR initiative as Milan hosted the 2015 World Expo, whose key themes were food and sustainability [2]. Moreover, in the 2016 the Assolombarda association, the city of Milan and the Polytechnic University of Milan signed the memorandum for a Zero-Waste Milan: "Smart City and Food Sharing, a Possible Alliance" to highlight the good practices of recovery and redistribution of food surpluses [3]. Lastly, in 2020, as the COVID-19 crisis unfolded, an increasing number of Milan's citizens, particularly the poor, people with limited mobility and older people, started experiencing a significant worsening of their access to good-quality food [4].

Back in February 2020, Milan succumbed to the first wave of the pandemic, and it is now grappling with a sweeping poverty outbreak. The pandemic has revealed for the first time the depths of economic insecurity in Italy's northern Lombardy region, which in the pre-COVID era used to generate 20% of the country's gross domestic product. The Coldiretti agriculture lobby estimates that in Milan, a city of over 1.3M inhabitants, the virus has created 300,000 so-called "new poor", based on surveys of the dozens of charity associations operating in the region [5]. Italy's new poor are people who are not on the radar of Italy's welfare system, and need to rely on informal, gray-market jobs and the help of friends and family.

4. Methods and Results

4.1. Theory of Change for Usobio's Food Rescue and Distribution Initiative

Food rescue, the practice of gathering food that would otherwise be wasted and redirecting it for human consumption, represents a critical opportunity to improve food security and reduce waste. The proposed CSR initiative was developed with a theory of change (ToC) methodology to help map out the inputs, outputs, outcomes and impact, while reflecting the iterative nature of the initiative [6]. This method helped to design more realistic goals, clarify accountabilities and establish a common understanding of the strategies to be used to achieve the goals.

Under this framework, Figure 1 below depicts the ToC diagram for the implementation of the CSR project addressing three main goals/impacts:

- Launch a rescue food initiative to fight against food waste.
- Increase food security among urban poor via food surplus redistribution.
- Build community solidarity through inclusiveness.

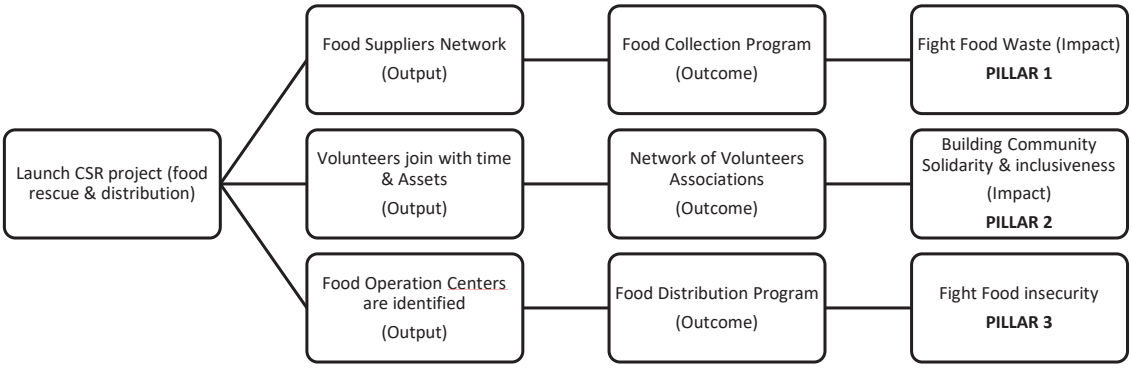

Figure 1. Theory of change diagram for the CSR of CPB Usobio.

4.2. ToC Pillar 1: Fight Food Waste

The first pillar of the plan aims to fight food waste by establishing a network of food suppliers willing to regularly donate the unsold food that would be otherwise be thrown away. The main pillar's output is the establishment of a network of food supply partners. Such a network can be established in various ways:

- Delineating a specific area of Milan (i.e., a district or just a few blocks) where supply partners shall be reached out to one by one to explain the initiative and ask for a partnership, aiming to collect and rescue their food surplus;
- Launching social marketing campaigns through social networks on Facebook or Instagram (i.e., Milan Expat Group; Vivi-Milano Group) to acquire potential supply partners and to inform them about the initiative;
- Web platforms can facilitate sending out notifications about food availability and collection time, boosting the food collection program. This can be achieved by partnering with already existing web platforms sharing similar goals to access their network of users. For example, the app Too Good to Go Italy (https://toogoodtogo.it/it accessed on 15 February 2021) already has a network of 10,000 food suppliers that sell the daily unconsumed food at a reduced price. Similarly, the same suppliers could also donate part of the unconsumed food (i.e., food that was not sold despite the publication of the discounted offer on the web platform).

Once a partnership with food suppliers is in place, the sponsoring organization can implement a food collection program (Outcome) where volunteers schedule pick-up times and organize a plan to rescue food from the agreed partners. Similarly, volunteers shall promote, through logos, banners and other advertisement tools, the use of bioplastic food containers and other related bioplastic products for the food rescue or for other activities outside the initiative. Volunteers are therefore the bridge between the eliminating-food-waste stream and the building-solidarity stream.

4.3. ToC Pillar 2: Build Community through Inclusiveness and Partnerships

The second pillar aims to build community solidarity and inclusiveness through volunteering and partnerships. This stream is placed at the center of the ToC depicted in Figure 1 due to the numerous interconnections with the other two streams and with the other outputs and outcomes. Volunteers can donate their time and skills to collaborating for the cause of fighting food waste and food insecurity and can donate assets (i.e., vehicles, tables, fridges, phones). Volunteers shall be deployed in food rescuing/collecting and food packaging and distribution.

There are several nonprofit associations active in Milan and the surrounding area that already have a well-established network of volunteers that could join the DP initiative through an ad hoc partnership. For example, the three main volunteer associations identified by the DP are the following:

- Banco Alimentare Onlus is a food bank network foundation located in Lombardy as well as in other regions in Italy.
- Pane Quotidiano Onlus provides the poor with food collected by bakeries and clothing donated by local citizens.
- Associazione Recup is a project that operates in the city markets of Milan to combat food waste and social exclusion. The beneficiaries are the same executors of the work, in this way a concept of collaboration and community between different people is created, promoting intercultural and intergenerational exchange that was previously lacking.

4.4. ToC Pillar 3: Fight Food Insecurity

The third pillar aims to fight food insecurity by distributing excess food to the community's most vulnerable members. This inclusive act will once again be made possible by the network of volunteers that will drive this initiative.

Food distribution will require an adequate venue where the variety of collected food can be regrouped and readied for distribution. CPB-Usobio could identify the venue in the following ways:

- Directly rent a venue (i.e., former shop on the ground floor, 50 square meters) and factor in this cost in the CSR budget (from EUR 15,000 to 25,000 a year).

- Ask the and volunteers if they have unused venues that they would be willing to donate to the initiative.
- Use the public areas available in Milan's 87 outdoor and indoor municipal markets (An authorization to use the space outside the municipal market's opening hours for pro bono food distribution can be acquired at no cost [7].) (market counters and tables depicted in Figure 2).

Figure 2. Picture and map extracted from (The City of Milano, Fondazione Cariplo, Working Group Està-Economia e Sostenibilità, 2018).

5. Sustainability Goals and Contribution to SDGs and 2030 Agenda

As part of the methods, we determined the extent to which the proposed project would meet the Sustainable Development Goals (SDGs) to evaluate its potential contributions to the 2030 Agenda. The ToC sets three key impacts to be achieved, which are associated with the following SDGs depicted in Figure 3 and described in detail below.

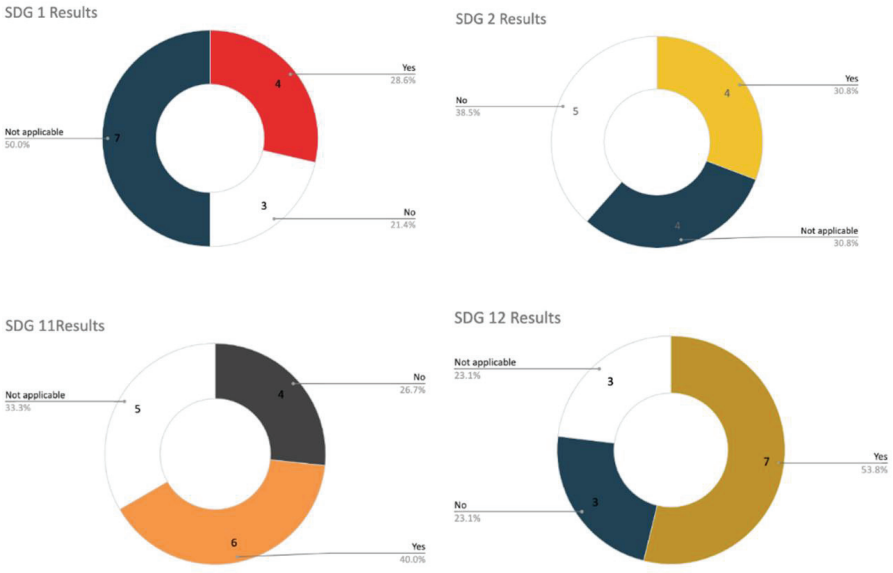

Figure 3. SDG scan ((Rodriguez, J. and Contreras, C., 2020) [8]) applied to the CSR initiative of CPB Usobio.

SDG 1: end poverty by eliminating food waste

As the COVID-19 crisis unfolded, an increasing number of Milan's citizens, particularly the poor, people with limited mobility and older people, started experiencing a significant worsening of their access to good-quality food. Containment measures, indeed,

together with closures of several associations and charities, triggered a systematic, city-wide intervention. Food security became an issue for a larger population: Milan's municipal welfare department allocated in December 2020 EUR 700,000 to food and housing assistance as part of the emergency measures to tackle the crisis. This year, when the first lockdown was underway, the municipality received 36,000 requests for food assistance. It catered only for 15,800 and later added 5400, while the rest of the requests did not meet the requirements for assistance [9].

The project will allow CPB-Usobio to contribute to this crucial fight against poverty and impact the most vulnerable members of Milan's community struggling with the economic crisis that the pandemic has caused so far.

SDG 2: end hunger by distributing food surplus

The percentage of food surplus redistributed at the national level is still not very high. Increasing this percentage is among the goals of the CSR project of CPB Usobio. Fortunately, in Italy, the normative framework is promoting the proposed CSR initiative. The Gadda Law (166/2016) was passed in 2016 with the precise objective of incentivizing the redistribution of surpluses and unused goods for social solidarity, allocating them to people in need [10].

The urban setting favors the redistribution of surpluses; there are many voluntary organizations with deep local roots in the city, which are thus capable of bringing together demand (the needy) and supply (the surpluses), which, in an urban context, are also very close to each other in spatial terms. For all organizations, the capacity to network, between themselves and with the institutions, is fundamental.

SDG 11: make city inclusive by building community solidarity

The CSR project will generate significant impact in each local community and on many levels, meeting a variety of needs. The initiative will help people struggling with food insecurity in local communities. Priority is given to the most vulnerable community members: children, elderly and the disabled—but anyone and everyone who needs food shall be welcomed.

A key added value of the initiative is inclusion. In Milan, the effort to combat food waste is one of the challenges that the voluntary sector has been contributing to with great dedication and incisiveness for some time. Over the course of 2017, 13 mapped networks recovered 123 metric tons of food, equivalent to 246,000 meals [11].These experiences concentrate on the recovery of surpluses at different stages and with other prospects: in the production phase, in connection with periurban agriculture; at local markets, with the direct participation of the beneficiaries who share what has been recovered; and in company banqueting and catering, in connection with initiatives of corporate social responsibility.

SDG 12: ensure sustainable consumption and production patterns

An analysis of national statistical data shows that in Italy, 5.1 million metric tons of food are wasted every year from a social perspective (i.e., not recovered to feed people), representing 15.4% of annual consumption and 91.4% of surplus food. The food waste is equivalent to the loss of EUR 12.6 billion a year (or EUR 210 per person a year), to a carbon footprint of 13 million metric tons of CO2 emitted in its production and to the needs of 1.5 million families in a state of absolute poverty [12]. Food surpluses and waste are generated at every stage of the food supply chain, but the stage chiefly responsible for forming both surpluses and waste is that of consumption, followed by the stages of production, distribution, catering and processing. Each stage has ample margins for improvement, both in reducing surpluses and in their redistribution for purposes of social solidarity.

The CSR project has an overarching goal embedded in its development: promoting sustainable consumption and production. On the one hand, the rescue food program will reduce food waste, and on the other hand, the sponsor organization will encourage the use of bioplastics as an alternative to fossil fuel plastics as per EU directive requirements.

6. Opportunities and Risks

Usobio's motto is that businesses should not only be profitable, but also be responsible entities. Enterprises are responsive to the stakeholders' needs. Therefore, enterprises must focus on productive stakes in the global economy and take social responsibility, "which creates long-term sustainability for corporate success by meeting the needs of all suppliers, investors and employees", into consideration for their own advantage [13].

There are many benefits of carrying out the community development project as a CRS initiative at both the company and community level.

At the company level, launching this project will increase the company's visibility, boost partnership opportunities and consequently increase sales. In particular, partnering with one or more web platforms (the Toogoodtogo app; bring the food, Avanzi Popolo 2.0; Myfoodie; Lastminute Sotto Casa; Spesa in Tempo [14]) will provide hundreds or even thousands of new retail clients. (Merchants are already registered on the web platform.)

At the community level, the project will provide benefits through food rescue and distribution, while involving volunteers, food suppliers and everyday citizens who will become more conscious of compostable plastics and sustainable food waste management solutions.

As with every business project, together with opportunities, risks might occur. Two groups of risks might be essential to determine, in advance, risks related to the project's implementation (risks for the organization) and the risks of not implementing the project (risks for the community).

The risks to the organization range from the profitability risk (the project might not turn out to be a profitable investment for the company compared to the core business activity) to COVID-19-related risks (food supply partners may shut down their activities or the pandemic might affect volunteer participation).

Not undertaking this development project may result in a loss of potential market shares that have not yet been exploited by the commercial strategy of CPB-Usobio. The health emergency has seen consumers make the shift—both quickly and *en masse*—towards purchasing food online. Consequently, take-away food businesses are booming, as are the requests for disposable tableware and food containers [15]. Lastly, without a corporate social responsibility project, the company might be subject to reputational risks as it would be perceived as not being connected with the customers and not engaged in supporting the community and ESG principles.

7. Recommended Initiatives

The ToC diagram and its description, as presented in Figure 1, have shown how the initiative is structured based on three pillars, aiming to achieve the following impacts on the community: eliminating food waste, building solidarity and community spirit and fighting against food insecurity. This section aims to provide the three actionable recommendations expected to make the project successful and effective for both the Milan community and CPB-Usobio.

7.1. Recommendation 1: Build Partnerships Rather Than a Solo CSR Initiative

The ToC highlighted the importance of building partnerships. CPB-Usobio is a for-profit company. Its CSR initiative requires resources (human and capital) related to the company's core business activity (i.e., manufacturing bioplastics products for the food industry). Therefore, launching the suggested CSR initiative autonomously would be excessively costly in terms of human and financial resources. Instead, for the proposed initiative, building partnerships remains the most viable option. Usobio could partner directly with food suppliers willing to adhere to its project, or with food waste web platforms willing to share their merchant database to boost co-marketing strategies, or with volunteers' associations and the local public initiatives.

7.2. Recommendation 2: Pursue an Agile Methodology as the Project Management Approach

The proposed CSR initiative is highly interactive; it can deliver immediate results that can be scaled up at a later point. For example, a food rescue initiative can begin simply by collecting a minimal quantity of food surplus (unconsumed perishable fresh food) from only one food supplier (i.e., a nearby restaurant in the neighborhood) to immediately distribute to the poor in the community (i.e., the homeless). Agile is designed to be a highly iterative and incremental process, where project stakeholders actively work together to understand the domain, identify what needs to be built and prioritize functionality [16]. Therefore, given the intrinsic nature of the project, we recommended pursuing an Agile approach.

7.3. Recommendation 3: Implement the Partnership Actions Using the Usobio Food Rescue Partnership Map

Figure 4 below depicts a partnership map to engage partners for the CSR initiative.

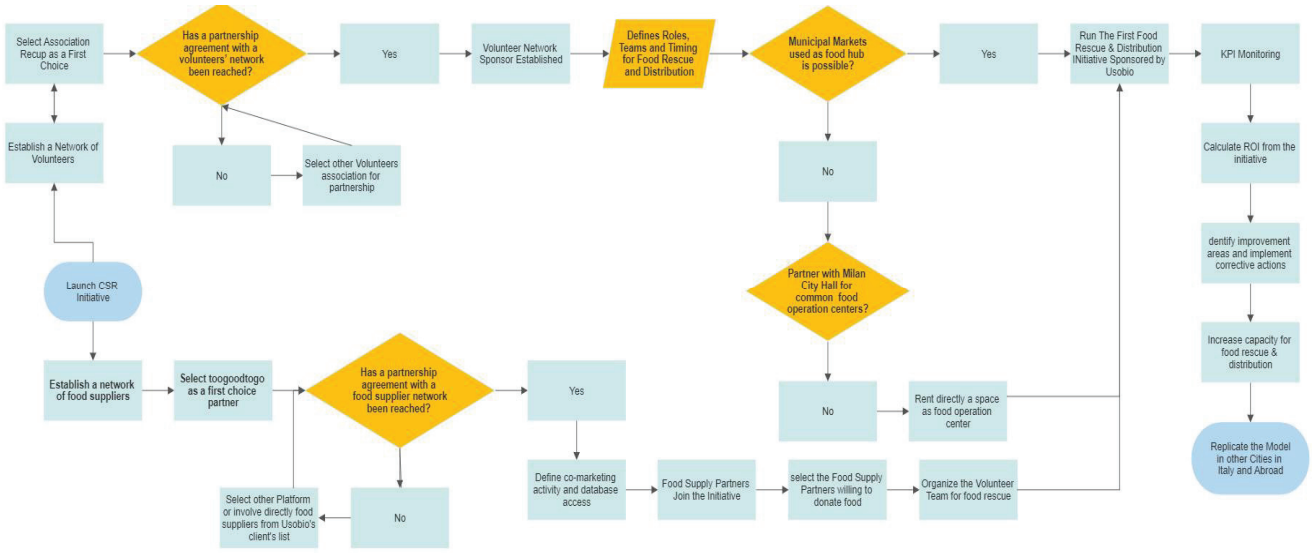

Figure 4. CPB Usobio food rescue partnership map.

While the project idea is simple, its implementation requires a step-by-step approach to minimize financial, reputational and organizational risks. The Food Rescue Partnership Map was designed as a decision flowchart to facilitate building up the networks with simple iterative steps. There are two key success factors: Establishing a network of volunteers and establishing a network of food suppliers.

For the first one (establishing a network of volunteers), the association Recup (https://associazionerecup.org/ (accessed on 23 March 2021)) appears to be the best option for CPB-Usobio among the various volunteer associations listed previously. Recup is a social promotion association founded in 2015 and committed to fighting food waste through the recovery and redistribution of unsold food from the municipal markets of Milan.

The association already has a clear and limited area of action (11 municipal markets); volunteers are trained and already well-known among the merchants of the markets; the association shares the vision and the mission of the proposed CSR initiative. Moreover, the association already has food operation centers in available areas within the markets where they carry out collection and distribution services.

For the second one (establishing a network of supply partners), among the various options, using the web platform toogoodtogo (https://toogoodtogo.it/it (accessed on 15 February 2021)) is the best option to achieve several food supply partners quickly. According to the website, one thousand and one hundred food suppliers (merchants) in Milan have already joined the platform and sell unsold food through the application by

preparing food portions placed in "magic" boxes, ready to be collected by the customer. Moreover, toogoodtogo launched a campaign called "patto contro lo spreco alimentare—deal against food waste" and is willing to partner with initiatives related to food waste or environmental awareness.

CPB-Usobio could benefit from co-marketing activities, promoting the initiative directly on the web platform and attracting potential food supply partners and potential new customers. As the app toogoodtogo does not provide any logistic support to partner merchants (food containers, boxes, bags), the packaging could become a business opportunity for CPB-Usobio.

8. Funding Required, Sources and Processes

Based on the CSR budget information provided by CPB-Usobio (CPB Usobio has identified a budget between EUR 30K and EUR 60K (yearly) available for the corporate social responsibility initiative), the business plan in Table 1 depicts the key elements needed to make the CSR initiative self-sustainable and potentially profitable in monetary terms for the sponsoring organization. Key assumptions refer to the initiative's sales target. The sponsoring client will have the ability to modify key assumptions and adapt the business plan accordingly to evaluate the potential return on investment. The initiative will be a 100% voluntary driven initiative, reducing, therefore, the investment costs for CPB-Usobio. The required funding sources can be referred to as three main cost centers: human resources, assets and communication and sponsoring.

Table 1. Business plan for pilot project CPB-Usobio.

Income and Expense Values in Euros						
		Year 1 [1]	**Year 2**	**Year 3**	**Year 4**	**Year 5**
Additional tableware (Sales target)	**600.000**	2%	20%	45%	80%	100%
Additional quantity sold through the CSR		10.000	120.000	270.000	480.000	600.000
Average Price per packaging sold	0.25					
Gross Margin (Revenues—30% production costs)		**1.750**	**21.000**	**47.250**	**84.000**	**105.000**
Expenses (Communication, Sponsor, HR)		**−24.000**	**−64.000**	**−39.000**	**−39.000**	**−39.000**
Operating Profit		**−22.250**	**−43.000**	**8.250**	**45.000**	**66.000**
Income taxes		0	0	−3.300	−18.000	−26.400
Net Profit		**−22.250**	**−43.000**	**4.950**	**27.000**	**39.600**
Internal Rate of Return	**3.32%**					

[1] The initiative shall begin in September 2021; therefore, year 1 shall be only 4 months.

The baseline idea is to funnel the usual budget for advertisements (EUR 30k–60k a year) into a single CSR initiative. Based on the conducted analysis, the initiative will have a return in terms of reputation, visibility and market share (sales) for the sponsoring organization and social and environmental benefits for the community.

Based on the assumption and the data provided, the IRR (internal rate of return) is estimated at 3.32%, corresponding to an equivalent of five additional medium-site clients for CPB-Usobio.

9. Conclusions

The proposed CSR initiative depicted in this DP is intended to be an example of social entrepreneurship; CPB-Usobio will sponsor a series of initiatives and partnerships that will produce positive feedback in terms of sustainability and that will also generate a return on investment for the client's market share, visibility and business opportunity.

The expected impacts of the plan are associated with three key Sustainable Development Goals (SDGs):

- Fight food insecurity for the most vulnerable in the community—those most hit by the pandemic and the economic crisis (SDG 1: end poverty).
- Match the food supply excess with the demand for food of the poor in the local community (SDG 2: zero hunger).
- Make the city more inclusive by involving the community and creating a sense of a common cause and partnership (SDG 11: make city inclusive).

The project indirectly supports SDG12 as the initiative will promote sustainable waste management solutions within the community, using bioplastic or other compostable products in the food supply chain and improving recycling practices or reducing food waste.

The project demonstrates how social entrepreneurship initiatives can be also financially self-sustainable as the sponsoring organization will have the ability to expand its client base through a CSR project. Additionally, the project demonstrates that social entrepreneurship can produce positive feedback loops in any context. The COVID-19 pandemic also showed how poverty is affecting new categories of our society, namely the "new poor" in developed realities. Stakeholders such as CPB Usobio srl can make a difference by adopting new technologies (web platforms and digital database) and benefit from partnership agreements, networking and inclusiveness.

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Apartadó's River Master Plan: Mitigating the Risk of Flooding in the Face of Climate Change in a Biodiversity Hotspot †

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Abstract: The Apartadó River Master Plan seeks to intervene 135 hectares and 4.5 miles along the river. The area is marked by the presence of indigenous and Afro-Colombian communities and is deemed a biodiversity hotspot. Severe flash flooding events occur in the river basin approximately every 6 to 10 years, exposing almost half of the city of Apartadó and its neighborhoods. With extreme weather events becoming more common due to climate change, the Master Plan seeks to increase resilience to flooding by replanting the river basin and using nature-based solutions to mitigate risk in the city's urban area.

Keywords: climate change; climate adaptation; climate justice; nature-based solutions; biodiversity hotspot; community mapping; urban resilience

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1. Introduction

Apartadó is a territory marked by the presence of ancestral communities and is considered a biodiversity hotspot. The city is highly vulnerable to the effects of climate variability and change with climate projections, indicating an increase in precipitation and temperature in an already humid area.

Apartadó is named after the suffix Dó, which comes from the indigenous Emberá word for river, with the Apartadó river crossing the city from east to west (Figure 1). The river's source is located in the Abibe mountain range at 1000 m above sea level, and it flows about 50 km into the Urabá Gulf in the Atlantic Ocean. Since the city was established on the river's floodplain, it has increased its susceptibility to flooding by reducing its drainage capacity [1] (p. 103).

The proximity to the river in the urban area has exposed communities to severe flash flooding events that occur approximately every 6 to 10 years. As many as half of the urban neighborhoods are affected by the natural flooding area of the river. With precipitation projected to increase around 10% due to climate change, extreme weather events associated with the river will also become stronger and far more frequent [2].

The Master Plan will intervene 135 hectares along 4.5 miles of the river basin. It hopes to replant the river basin and use nature-based solutions to mitigate risk in the urban area, to strengthen resilience to flash flooding events. The project will also triple the green space per inhabitant by proposing complementary urban green spaces along the river basin [3].

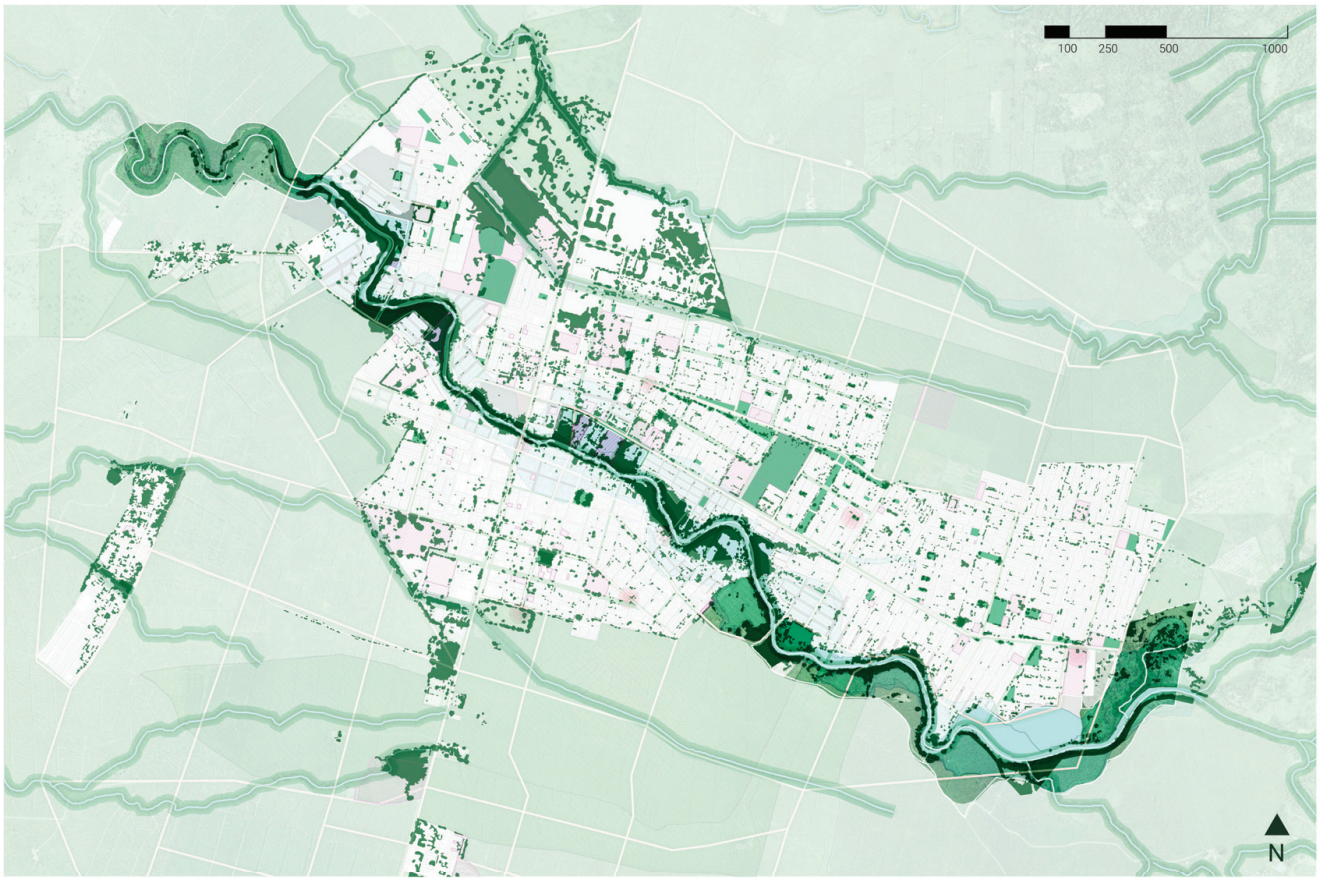

Figure 1. The Apartadó river crosses the city from east to west; units are expressed in meters. Source: by the authors.

2. Regional Context

The municipality of Apartadó is located in the Urabá region within the department of Antioquia, in the northern part of Colombia (Figure 2). It is characterized by its strategic location and its potential based on biodiversity. The region is part of the American intertropical zone. It is home to one of the 36 biodiversity hotspots recognized by the IOC (International Conservation Organization), known as the Tumbes-Chocó-Magdalena corridor. This area is home to 10% of the planet's biodiversity [1] (p. 17) and allows a biological exchange between North, Central, and South America. This is reflected in the 500 and 1000 million individuals of birds that cross the area annually, as well as in the humpback whales and Caná turtles [1] (p.18).

The ecological structure of Urabá has as its main features: the Atrato river basin with the mangroves at its mouth, the beaches of the Urabá Gulf, the Rionegro cove, and the Nudo de Paramillo mountain range from which the Serranía de Abibe is derived. The rivers that irrigate the main municipalities of the region are born in the Serranía de Abibe and discharge into the León River (Chigorodó, Carepa, Currulao, Guadualito, Turbo, Caimán Nuevo, Caimán Viejo, Bobal, Necoclí rivers, Apartadó, and Río Mulatos).

The Serranía de Abibe is a steep mountain range that causes the rivers to have narrow and canyoned valleys. When the channels reach the flat area, the speed of the water decreases, and the sediments are deposited, forming alluvial plains [1] (p.103). This change in slope causes the rivers to meander, and the main flow is divided into several secondary drains. This condition also causes a natural deficiency in the drainage capacity of the river basins.

These geological conditions allow the water infiltration that descends from the mountains into an essential reserve of underground water known as an aquifer. The central recharge zone is located along the foothills and is the primary source of supply for the local industry

(banana plantations) and more than 30 rural communities [1] (p. 60). These rivers are then subjected to permanent impacts that compromise the sustainability of the water resource.

Figure 2. Location of the Apartadó region in the northern part of Colombia. Source: by the authors.

The Urabá region is also characterized by the confluence of cultures, in this case, the Caribbean, the Pacific, and the Andean, and the presence of Afro and indigenous communities. The region is home to 32 reservations with 72 indigenous communities of the *Embera Katio*, *Embera Chamí*, *Kuna*, and *Zenú* ethnic groups [4]. It also houses six community councils of Afro-Colombian, *Raizales*, and *Palenqueras* communities [5].

Regarding productive activities in the region, banana and plantain production stand out, accounting for almost 75% of the Colombian banana production [6] and extensive cattle ranching [1] (p. 37). Despite these activities, and although the banana industry represents an essential source of employment in the area [1] (p. 64), the NBI (unsatisfied basic needs) indicators are worrying. In the case of Apartadó, there is a percentage of 14.4% of the population with unsatisfied basic needs [7], and 2.99% of the population lives in conditions of misery [7]. In addition to this, it is essential to mention that the Urabá region suffers from delays in infrastructure and institutional strength, which has led to informal land tenure and the susceptibility of the territories to armed conflict and forced displacement.

3. Climate Change in Apartadó

Colombia and the Urabá region are heavily prone to the effects of climate change. Even though Colombia emits 0.5% of the worldwide GHG emissions [8], it will face major changes that require extensive adaptation strategies. This is to protect the country's economy and the great number of endemic species that are hosted in Colombia's ecosystems.

Recognizing the need to adapt to and mitigate climate change, the Antioquia department is the first to declare a climate emergency. As part of their action plan, the government of Antioquia has launched the initiative "parks of the rivers", which aims to generate 50,000 square meters of new green public spaces [9]. These parks will help with risk exposure and flooding protection along river basins that coexist with cities and municipalities. The Apartadó river Master Plan has been prioritized as one of the most strategic projects of this initiative because it combines the intervention of the Apartadó river and the update of the city's zoning plan.

Even though the Urabá region is located in a biodiversity hotspot, it is one of the areas with the greatest loss of biodiversity in the country and holds high rates of poverty [10] (p. 8). The region is experiencing the effects of climate change already, and its temperature is expected to increase by 3 °C in the lowlands by 2100 [10]. In the municipality of Apartadó, the situation is similar, with the temperature projected to increase by 1.8 to 2 °C between 2041 and 2070 [11] (p. 35). When it comes to precipitation, Apartadó's rain regimes will vary between −10% and 10% [11] (p. 31), which will exacerbate droughts and the rainy seasons.

The increase in extreme weather events associated with climate change is critical for Apartadó since the city was established on the river's floodplain. This condition has exposed communities along the river basin to severe flash flooding events approximately every 6 to 10 years. In Apartadó's urban area, as many as 20 neighborhoods are affected by the natural flooding area of the river, which is equivalent to almost 50% of all urban neighborhoods (Figure 3). With climate change expected to increase the probability of extreme weather events and precipitation patterns becoming more unpredictable, the flooding events of the Apartadó river are expected to become more frequent and extreme.

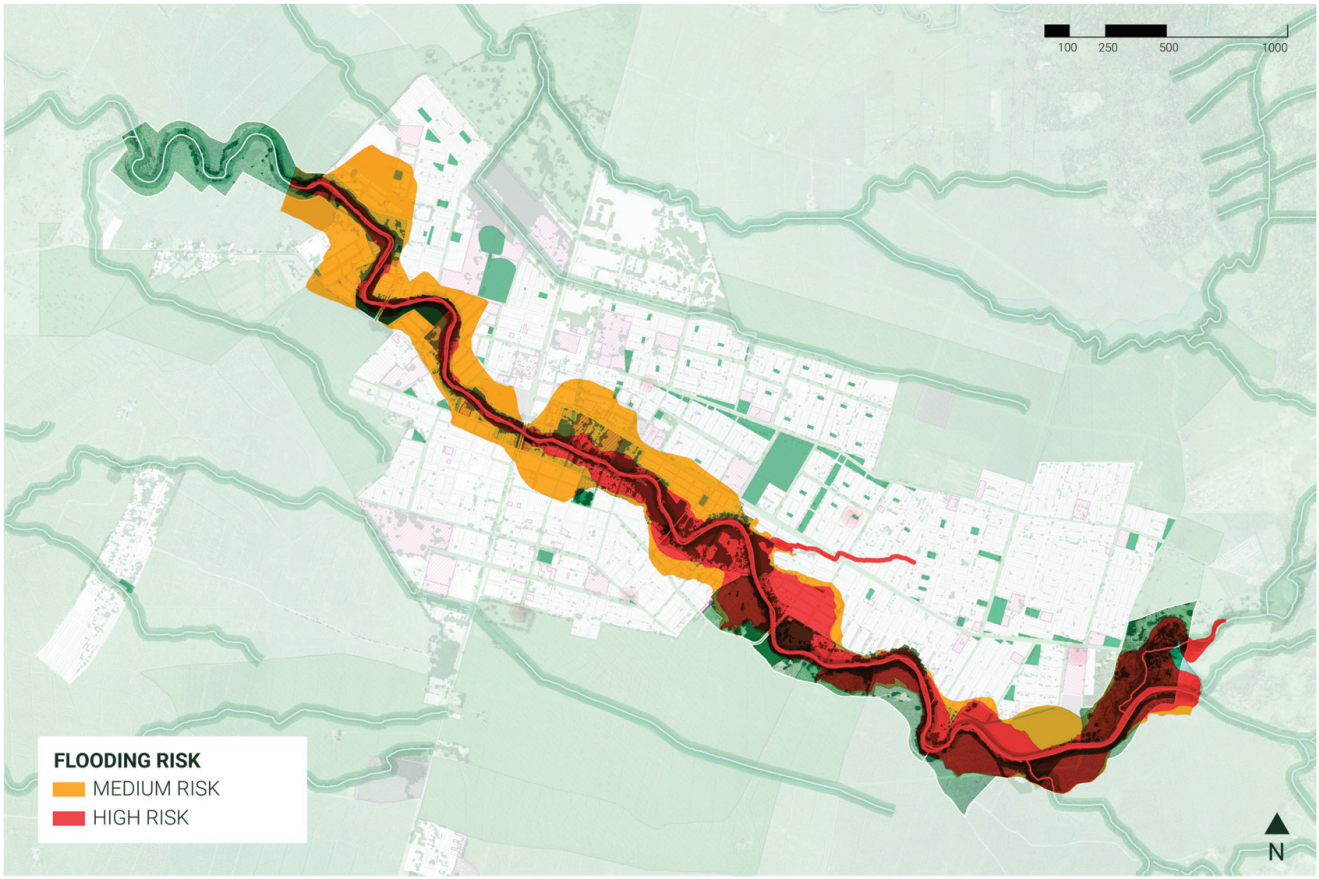

Figure 3. Risk of flooding in Apartadó due to the river. Source: by the authors.

Adapting to climate change and achieving local risk management through sustainable land use and development will be key in helping Apartadó gain more resilience. With the inclusion of the Apartadó River Master Plan within the zoning plan of Apartadó, the city administration expects to mainstream climate adaptation in the urban and rural portions of the river while promoting environmental planning along the river basin.

4. Alignment with the Sustainable Development Goals

The Sustainable Development Goals (SDG) were adopted in 2015 as part of the 2030 Agenda for Sustainable Development proposed by the United Nations. The goals constitute

an *'urgent call for action'* [12] to create a global partnership between all countries to achieve them. The seventeen SDGs were established without any hierarchy, giving them the same value and importance worldwide. However, other theoretical approximations of the SDGs provide differential scopes of their impact, as is the case of the 'Wedding Cake' approach proposed by the Stockholm Resilience Centre. This concept divides the SDGs into three 'layers' of action ('economy', 'society' and 'biosphere') that are interrelated and tackle different scales.

The idea behind the 'Wedding Cake' approach is to organize the goals to place planetary stability as the foundation of the development goals, followed by society, and ending with the economy at the top. This is to say that the SDGs need to be achieved within the planetary boundaries [13] that have been defined by the scientific community to have a stable planet and atmosphere. These latter are a prerequisite for any society, and as follows, societies are a prerequisite to the economy. It is easier to understand their impact on a sustainable future by organizing the SDGs into these categories.

The foundational biosphere layer from the 'Wedding Cake' approach gains more relevance when considering that the most common category of the top ten risks identified by the *Global Risks Report 2021*, 16th edition (both in likelihood and impact) are environmental risks [14] (p. 12). This is coupled with the fact that the top three risks in terms of probability were assessed as extreme weather, climate action failure, and human environmental damage [14].

When considering the biodiversity present in Colombia and the fact that the country has abundant water resources, framing sustainable development under a biosphere protection approach seems logical and highly pressing. This is why the Apartadó River Master Plan seeks to tackle mainly the SDGs associated with biosphere protection, which are SDG 6 (clean water and sanitation), SDG 13 (climate action), SDG 14 (life below water), and SDG 15 (life on land). It also contributes to SDG 11 (sustainable cities and communities), providing urban green spaces and contributing to urban resiliency through ecosystem-based adaptation.

The project's alignment and achieving SDGs show the importance of urban and environmental planning initiatives. These initiatives contemplate not only more sustainable communities but understand the role of urban ecology and other ecological processes in the protection of the biosphere and ultimately guaranteeing a stable atmosphere.

5. Conceptual Framework

For the purposes of this paper, a master plan is understood as a dynamic long-term planning document that provides a conceptual design to guide future growth and development [15]. It is also based on public sector input, surveys, planning initiatives, existing development, physical features, and social and economic conditions [15].

In terms of climate adaptation, the term 'urban resilience' is understood by the description provided by UN-Habitat, which defines it as "*the measurable ability of any urban system, with its inhabitants, to maintain continuity through all shocks and stresses, while positively adapting and transforming toward sustainability*" [16]. Resilience is also considered an accelerator for sustainable urban development [16].

6. Methodology

The methodology for the Master Plan included three stages: due diligence, diagnostic, and formulation. The three stages contemplated community mapping and participatory planning workshops with different communities to understand their relationship with the river at a cultural and economic level and to identify their knowledge of ecological restoration.

6.1. Due Diligence

Due diligence for the project included reviewing the information provided by the city of Apartadó on subjects concerning biodiversity, risk management, previous urban design projects for the river, the zoning plan, the major's development plan, and other regional initiatives related to climate change and economic growth.

The initial stage also included a resilience mapping exercise using an adaptation of the SAGE (Sustainable Adaptive Gradients in the Coastal Environment) framework for assessing resilience in infrastructure projects by framing the guiding questions of each of the Eight Gradients of Resiliency [17] to extract the local issues of resilience from workshops with different stakeholders. The gradients were divided by stakeholders depending on their role in the municipality, and recurring themes between stakeholders were extracted to identify the Master Plan's guiding principles.

6.2. Project Diagnostic and Approach

For the project diagnostic and approach stage, the methodology included analyzing and interpreting the information reviewed during due diligence and cross-analyzing it with information compiled through community outreach. The phase also included fieldwork and assessment along the river, especially in urban areas where erosion issues are more prominent.

Community mapping strategies were also implemented, focusing on a city scale to identify issues and proposals that needed to be incorporated into the zoning plan review while also assessing the information that could be tackled by the Master Plan on a smaller scale.

Finally, the project diagnostic and approach provided a report with key findings and recommendations to be included in formulating the Master Plan.

6.3. Formulation

The formulation of the Master Plan had, as a starting point, the essential findings and recommendations of the project diagnostic and approach, along with community outreach activities based on the five guiding principles for the Master Plan resulting from the resilience mapping. These workshops included the participation of ancestral communities, community leaders from the 20 neighborhoods impacted by the project, young leaders, and participatory planning entities.

The Master Plan seeks to tackle disaster mainstreaming with an environmental and climate justice approach. From a technical perspective, it was formulated with ecosystem-based adaptation strategies, such as forest protection and participatory ecological restoration, and using design principles based on "water sensitive cities".

7. Results: The Master Plan

After analyzing the results of the resilience mapping exercise (Figure 4), five recurrent topics constantly surfaced during community workshops about the river and its adaptative capacity. The key themes were identified after speaking with the different stakeholders and were identified as follows: (1) The importance of the river as a city landmark and an urban development axis; (2) the importance of risk management within the river basin; (3) the environmental damage caused to the river and the need for ecological restoration; (4) the lack of social appropriation surrounding the river (despite its ancestral and ecological importance); and (5) the weakened governance of the region that could prevent the project from being carried out in the long term.

From these five key themes emerged the five guiding principles for the Master Plan, which are summarized in the following concepts: The river as an axis for sustainable urban development, the river as an alive system (*río vivo*), the river as a safe system (*río seguro*), the river with a specific identity associated with it (*río con identidad)*, and finally, the river as a project that becomes a reality for the city (*río una realidad*). These five principles resulted in five lines of action that guided the formulation of the Master Plan and the strategies associated with it. Since the principles are derived from the resilience mapping exercise, their lines of action are expected to tackle the major challenges the river faces in terms of urban resilience, climate adaptation, and risk management with a locally tailored approach.

In the following subsections, the document elaborates on the different actions and approaches in each line of action and how they contribute to mainstreaming disaster risk reduction.

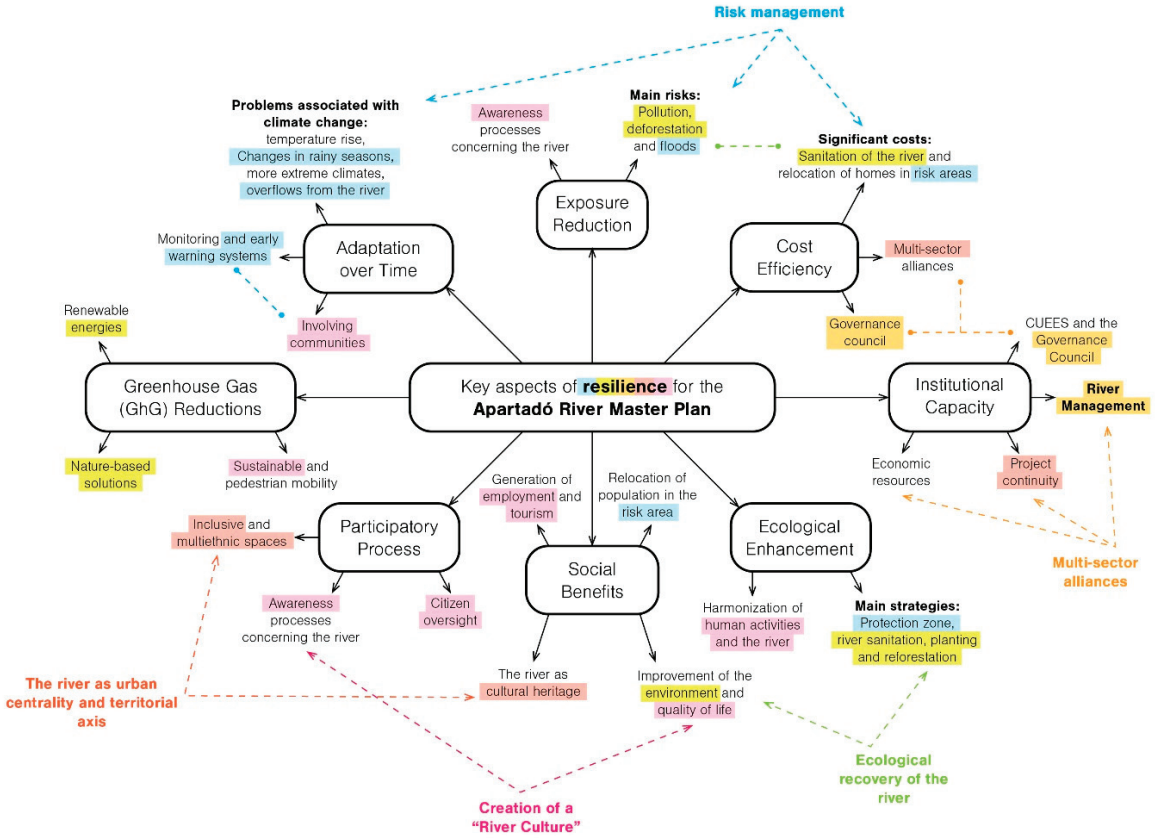

Figure 4. Resilience mapping exercise with key stakeholders. Source: by the authors.

7.1. The River as an Axis for Sustainable Urban Development

In terms of urban and regional planning, the main objective of the Master Plan is to make the Apartadó river the central element in the city's planning and development strategy. The municipality has to revert decades of development tactics that ignored the river to achieve this. As a result, making the river an axis of sustainable urban development requires changes in zoning legislation, building codes, and land use policy, among others. Those above were tackled in the review of the city's zoning plan, which was also carried out in 2021.

As a more specific approach, the variables formulated within the Master Plan were centered along the lines of creating a robust urban space network, defining the necessary civic amenities to place along the river, and incorporating a sustainable transportation system that could lessen GHG emissions while connecting the river to the proposed system of calm streets that spreads throughout the city.

7.2. The River as an Alive System

Considering the incredible amount of biodiversity in Apartadó, but also the pluri-diversity reflected in indigenous tribes, afro communities, and other cultures present in the city, community empowerment will be a crucial element in achieving ecological restoration.

The environmental strategy of the Master Plan is based on ecosystem-based adaptation and nature-based solutions, which were designed conjointly with these communities. Their knowledge is a crucial pillar of environmental restoration, as there is a strong connection between them and biodiversity conservation.

Some of the strategies mentioned above include:

- Partnering with farming, indigenous and afro communities, and the different stakeholders in the river basin.

- Participatory ecological restoration of the river's banks, including cleaning, stabilization, and replanting.
- Providing the communities with technical knowledge.
- Reforestation processes, in hand with traditional indigenous *doctors*.
- Planning workshops for the recognition of landmarks in the river's basin.
- Planting of ancestral medicinal plants.

7.3. The River as a Safe System

One of the most important findings during community outreach was that the historical management of the river basin and the deforestation processes carried out in the river's source were affecting its overall resiliency. Specifically, when talking to ancestral communities, the most accepted idea about why the river became a threat was ecological degradation processes that increase sedimentation and erosion around the river basin.

When considering the different communities living close to the river, mitigating and preventing the risk of flooding is essential. Allowing these communities to coexist with the river safely is an opportunity to reach resilience while preserving the cultural and historical relationship they have sustained with the affluent for decades.

The main strategies for risk management include:

- Formulating adaptation and resilience guidelines for the neighborhoods adjacent to the river. A strategy called the "eco-resilient neighborhoods".
- Creating green buffers and flood detention zones that work as public spaces.
- Designing sustainable urban drainage systems (SUDS) adapted to the local environment and vegetation.
- Prioritizing community councils and indigenous reservations for detailed risk studies.

7.4. The River with a Specific Identity Associated with It

The uniqueness of the Apartadó river is based on its abundant biodiversity and on the identity of the ancestral communities that live by the river. During participatory workshops, Indigenous and Afro-Colombian communities identified the river as historical and environmental heritage of their culture. They acknowledged that the degradation of the affluent was endangering some of their ancestral traditions. An example of these is the traditional indigenous games (similar to sporting events) in which communities use the river to practice apnea and rafting competitions. Indigenous communities can no longer take part in these traditional sports due to reducing the river's flow and its contamination.

As a strategy to preserve the particular identity of the Apartadó river, the Master Plan seeks to promote ancestral representation through elements in urban design and activities within the park that highlight the historical activities carried out in the river basin. This includes traditional indigenous games and indigenous markets. It also provides community spaces to share ancestral knowledge. The plan also seeks to promote eco and ethnotourism associated with the river's history and contemplates training community leaders to carry out these complementary economic activities.

Another recurrent theme is the lack of initiatives to protect the river and basin from ecological degradation from agro-industrial activities, public sewage management, and improper domestic waste management. The Master Plan seeks to approach ecological degradation by proposing a citizen oversight roadmap to promote accountability in public and private processes related to the river's protection and conservation. Furthermore, the plan will implement an aggressive environmental education program that will incentivize communities to take better care of the river, including citizen science activities and community reforestation strategies.

7.5. The River as a Project That Becomes a Reality for the City

To carry out the Master Plan, the municipality needs to form multisectoral alliances. A strategy for achieving this is to identify the stakeholders with properties along the river basin and create public-private partnerships to carry out commercial and conservation

projects along the river. Another strategy is the payment of urban transfers from other initiatives within the intervention zone for the Master Plan.

Urban transfers in Colombia are portions of land or resources that have to be destined by developers and promoters to create public spaces, civic buildings, transport infrastructure, and other public amenities. They provide effective urban support for real estate developments. By linking urban transfers to the Master Plan, resources for urban development can be concentrated along the river's axis, improving its commercial value and funding other necessary actions, such as reforestation or the creation of new urban spaces.

The current administration aims to establish the Master Plan as a legal planning instrument that is also reflected in the new zoning plan for the city. However, technical studies still need to be carried out to consider the Master Plan a viable tool for long-term planning.

8. Closing Remarks

Implementing climate adaptation strategies that allow for mainstreaming disaster can be challenging for a city like Apartadó, with specific conditions tied to biological and cultural diversity. As was shown by the resilience mapping, addressing resilience issues for this type of setting, we need to consider risk management, governance issues, environmental degradation, social inclusion, and cultural representation.

The Apartadó River Master Plan seeks to encompass all these variables to help create a proposal that can strengthen disaster response within the city. It also seeks to promote climate and environmental justice strategies, cultural appropriation programs, and public-private partnerships to tackle low governance. The role that land use and urban planning play in climate adaptation is focused on urban interventions, socio-ecological strategies, and risk management.

The methodology used in this project also demonstrates the importance of centering adaptation interventions around communities and local stakeholders that can guide the narrative of disaster response while incorporating unique cultural elements to risk management. This allows for a climate and environmental justice approach that promotes social empowerment within communities and enables decision-support frameworks for the project.

Although resilience is often thought of in terms of risk management and disaster response, the Apartadó River Master Plan argues that true resilience can only be achieved when attending to the specific conditions of local communities. By strengthening resilience through tailor-made solutions within socio-ecological systems, development planning has higher opportunities of being successful in facing the challenges that the climate crisis will bring forward.

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Proceeding Paper

Understanding ESD: Perceptions and Views from Guatemalan, Nicaraguan, and Costa Rican Educators †

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Abstract: This study is a descriptive account of participating teachers from Central America during a professional development program designed to support the curriculum integration of education for sustainable development (ESD). The analysis of the collected data provides insights on the participants' initial perceptions and understandings of ESD-associated mechanisms and of social, environmental, and economic sustainability issues. The findings suggest that the majority of the participants (N = 42) made efforts to incorporate sustainability issues into the curriculum regardless of previous ESD training or experience. The participants also demonstrated a need to receive training on the processes, strategies, design tools, and mechanisms for delivering learning about and for sustainability in daily instruction.

Keywords: education for sustainable development; education for sustainability; teacher preparation; sustainability learning

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1. Introduction

The intertwining peril of worldwide environmental degradation and social injustice is an unavoidable reality facing us all. Educators must teach about such realities as students are becoming increasingly aware of the disastrous conditions that await them in their adult lives and demand an education useful enough to deal with a dying world (Marris, 2019). In her address to the 2021 UNESCO World Conference on Education for Sustainable Development, Indonesian youth Rajwa Pandhita stated, "Building a whole new lifestyle is not an easy [goal], but slowly and together I'm sure we can do it. But education needs to give us the tools to do this. Learning not just about our planet but for our planet needs to be part of every young person's education, everywhere in the world" [1].

In Central America, climate and sociopolitical crises are disproportionately impacting the marginalized, working population living in underdeveloped regions. Consequently, healthcare, potable water, fuelwood, fisheries, and crop productivity are increasingly scarce and reduced in these regions [2]. Rural communities in Guatemala and Nicaragua account for more than 40% of the population and depend on natural resources to make their basic ends meet [3]. Furthermore, Guatemala has 90.6% of its citizens living at or below the poverty line [4]. Nicaragua is one of the least developed countries in all of Latin America, with little access to basic services (including education) and enough political instability and oppression to incite mass migration to other countries, such as Costa Rica [5,6]. While Costa Rica demonstrates some of the highest literacy rates in Latin America and free access to quality K-12 education, governmental corruption prevails and has led to the unchecked destruction of valuable natural resources and an increasing socioeconomic gap between the communities.

The various sustainability crises affecting such Central American nations have made visible the need for a different kind of education, one that can equip students with the

knowledge and skills needed to move society toward social, environmental, and economic well-being—education for sustainable development (ESD) [7]. ESD focuses on learning about, and actively addressing, sustainability issues; as such, ESD emphasizes a future-oriented, systemic thinking, fostering a learning process facilitated by critical questioning (i.e., raising questions about equity and social justice) and experiential learning designed to foster both innovation and empathy [8]. ESD is a programmatic framework that informs the pedagogical strategies used to engage students in relevant learning. As such, ESD highlights the importance of cultivating the knowledge, the ways of thinking, and the behaviors needed to address the current sustainability challenges [8,9]. ESD educators anchor activities within the local context, hence positioning all members of a learning community as stewards of their land that in turn can make a positive global impact [10].

During the May 2021 UNESCO World Conference on Education for Sustainable Development, more than 2800 stakeholders from the fields of education and environment studies, along with 88 ministers and vice ministers from around the world, signed the Berlin Declaration on Education for Sustainable Development [11]. This agreement commits signatories to transform all pre-K-to-adult education to incorporate ESD as a core, organizing framework. The members are required to identify and rectify socioeconomic gaps and barriers within the respective educational systems and to prepare teachers to incorporate ESD in daily instruction. Given the vast numbers of Central Americans impacted by social injustices and environmental inequities, ESD is a framework worthy of full consideration.

While international research on the adoption of ESD abounds, there is no available literature on this topic for any country in Central America. For countries such as New Zealand and South Africa, researchers report that ESD principles and processes are not properly conceptualized by in-service teachers, school principals, and academic supervisors [12]. Furthermore, teachers in such countries were found to have low eco-literacy levels and little confidence in their own abilities to address such sustainability issues, particularly environmental issues [13]. Findings from a study that compared the environmental education in Finland and the Netherlands suggest that in-service teachers lacked confidence in their own abilities to instruct others on environmental issues, which many perceived as too technical and complex to address [14]. The United States also faces constraints in their teachers' level of mastery and confidence in teaching environmental, social, and economic issues as stand-alone courses or integrated lessons [13]. The findings also highlight the dearth of U.S. teacher education programs providing mandatory ESD training for pre-service teachers; this is the likely source of the teachers' expressed inadequacies [13].

Teachers are key to beginning a successful transition towards ESD. Both pre-service and in-service teachers need to receive high-quality training on ESD pedagogical approaches and resources. All teacher education programs must include opportunities to learn about the causes and consequences of local, regional, and global sustainability issues, along with the current and prospective efforts to address such issues. Current and future teachers must be adequately prepared on how subject-matter instruction can and must be used to deliver an education that meets academic standards and core academic skills while also fostering the goals specific to learning for sustainability. Efforts to provide such training to our teachers must begin with a full exploration into what teachers understand as ESD and what it means to live and work in sustainable ways. We must understand what knowledge and experiences educators have about tools and strategies that are conducive for supporting formal academic instruction that fosters socioenvironmental sustainability. Gaining such baseline understandings can help inform national policies on pre-service and in-service teacher programs to effectively prepare a teaching population that adequately incorporates ESD in its classroom practices. In taking up this imperative, the present study was conducted with the purpose of answering the following research question: what knowledge, perspectives, and experiences do teachers in Central America have with respect to ESD? This study was developed to contribute to the current efforts in preparing educators in Central America to integrate ESD processes and strategies in curricular practices.

2. Materials and Methods

2.1. Recruitment of Participants

The recruitment of participants for this study commenced from October 2020 to January 2021 by utilizing the available social media and professional connections with educators in Nicaragua, Costa Rica, and Guatemala. The call for participants in these countries was delivered as part of an invitation to a freely available professional development event that focused on the design tools and pedagogical approaches for delivering ESD-integrated subject matter instruction. All the potential participants received general information about the event as well as information about the opportunity to participate in this survey study, along with the necessary human-subject approvals. This event was attended virtually due to the COVID-19 pandemic that precluded any in-person interactions. Hence, the online registration included a voluntary 28-question online questionnaire to be completed prior to the PD event. All 42 participants for this event opted to answer this online questionnaire. No additional tasks beyond the completion of the online questionnaire were assigned for the participants as part of this first-phase exploration.

A total of 42 participants joined this study, from which 21 are from Guatemala, 12 from Nicaragua, and 9 from Costa Rica. Two participants identified as male, and the remaining 40 identified as female. At the time of taking the survey, 15 participants were working at a private high school (grades 7 through 11/12), and eight were working at a public high school. Six participants were working at a private elementary school, and three taught at a public elementary school (grades 1 through 6). Three participants were working at a public K-11th/12th grade institution, and one was working at a private K-11th/12th grade institution. Three participants were working at a higher education institution, and two reported not working at any type of formal educational institution at the moment of the survey. Only one participant declined to share their current employment status.

2.2. Data Collection

Due to the virtual nature of the study, the data were collected through a Qualtrics-operated survey. Questions 1 through 14 (Baseline Information) elicited demographic information as well as teaching experience; the participants recorded the number of years and grade levels taught at their current school, the languages they use, and all the subjects they taught at the moment of responding to the survey. Question 16 elicited the participants' conceptual understanding of ESD (ESD Definition), and questions 17, 18, and 19 asked the participants to describe what they perceived to be the most concerning environmental, social, and economic issues at a personal level (Sustainability Concerns). Questions 21, 22, and 23 elicited the level of frequency (ranging from "never" to "nearly daily") at which the participants integrated social, economic, and environmental issues within their teaching of subject matter (ESD Integration). For questions 24 and 28, the participants indicated whether they had received courses or training on ESD during the period prior to working as an educator (Prior ESD Training) or during their in-service work (In-Service ESD Training), respectively. All other questions in this survey (items 20 and 25–27) were not utilized for this study.

2.3. Analysis

The survey responses about the ESD Definition (i.e., item 16) were analyzed by using the principles of grounded theory [15] to identify the emerging themes from the expressed understandings and views of ESD. All responses originally written in Spanish were initially reviewed and codified in their original language. The responses and subsequent codes were then translated into English. Each answer in English was subject to multiple rounds of review to ensure accurate translation of the intended messaging. Notes or memos were taken during analysis to highlight key terms or segments in expressed responses. The process of identifying such key terms/segments was untethered from the ESD framework in order to allow for such codification to emerge from the voices of the participating teachers. The highlighted segments in the responses served as a first level of codes. The review of

subsequent responses informed an on-going revision of such first-level codes that were then aggregated into higher-level codes representing broader themes across the participant responses. Higher-level codes were in turn reviewed and revised to ensure that each broad theme accurately represented the participant voices. Forty-two first-level codes and five higher-level codes were produced using this iterative analytic approach (see Figure 1).

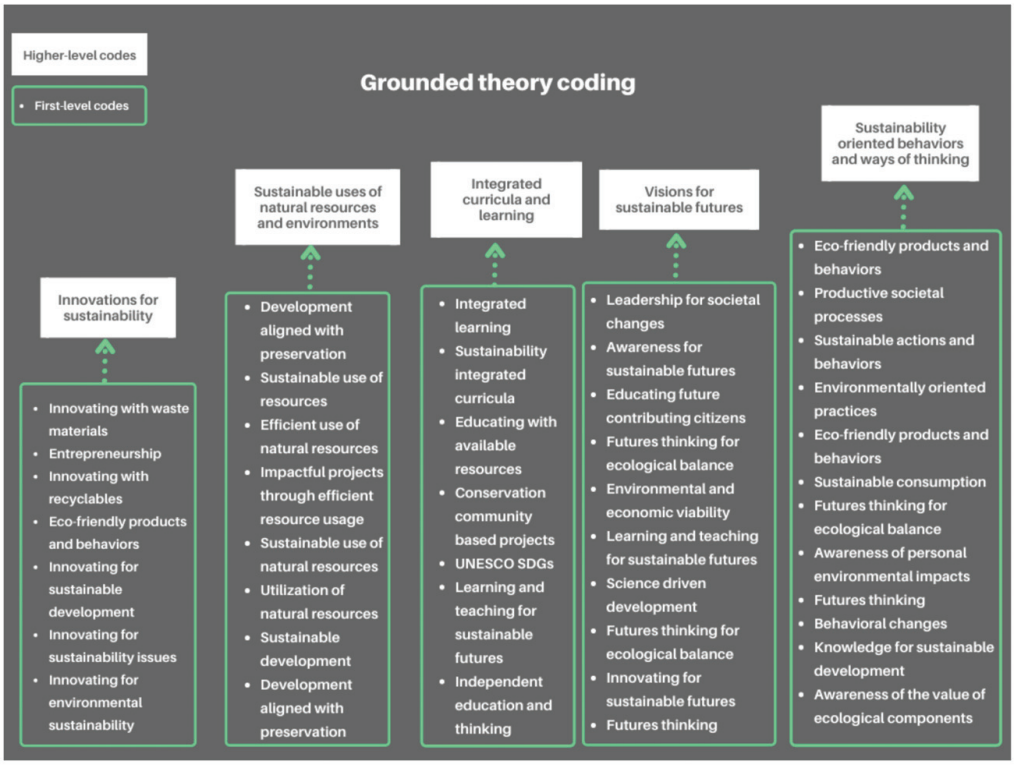

Figure 1. The resulting configuration from grounded theory coding. White bulleted phrases feature the first-level codes. The respective higher-level codes are featured in white boxes.

It is important to note that the words sustainability and sustainable were included in the first-level codified responses that alluded to social, environmental, and economic issues, benefits, or components. First-level codes for responses that only mentioned natural resources, environmental issues, or natural environments were coded with one of the environment and natural resources themes in order to adequately clarify among the emergent themes.

Furthermore, the term *futures* was used to code responses related to the benefits of current and future generations.

The higher-level codes detailed in Figure 1 were in turn analyzed against the ESD learning processes and learning strategies, as explained by Tilbury in the report Education for sustainable development: An expert review of processes and learning, commissioned by UNESCO [16]. These include processes of collaboration and dialogue; processes which engage the whole system; processes which innovate the curriculum as well as teaching and learning experiences; and processes of active and participatory learning and the strategies of learning to ask critical questions; learning to clarify one's own values; learning to envision more positive and sustainable futures; learning to think systemically; learning to respond through applied learning; and learning to explore the dialectic between tradition and innovation.

Analysis of the alignment between Tilbury's processes and the strategies and higher-level codes involved a systematic review of the first-level codes organized by each corresponding higher-level code, followed by a contrastive analysis with the ESD processes and strategies to determine semantic alignment. As such, higher-level codes that contained

first-level codes that aligned with one or more process and/or strategy were recorded as concurring with an ESD process and/or learning principal.

The survey questions (i.e., items 17, 18, and 19) related to Sustainability Concerns were coded as described above by following grounded theory coding [15]. The responses were first iteratively reviewed and translated from Spanish to English. The main message in each response was highlighted, and a subsequent list of associative thematic markers was produced for each sustainability concern. As an example, many participants answered that one of the economic issues that concerned them the most was *falta detrabajos* (lack of jobs), *pocos empleos* (few available jobs), *desempleo* (unemployment), or *pocas oportunidades para encontrar empleos* (few opportunities to find jobs). Therefore, these answers were considered to report the same theme of *lack of employment opportunities*. In this way, a list of reported themes for each sustainability issue was generated. Once these lists were generated, the answers for each question were read again, and based on its content, an answer was tabulated under the pertinent theme.

3. Results

3.1. Prior Experience and Education (Baseline Information)

At the time of this survey study, 29 participants reported working in the field of education for over five years, six participants had been working for three to five years, four participants had been working between one to three years, and three participants had been working for less than one year in education. Thirty-five participants had completed an undergraduate degree, five participants held a master's degree, and two had only completed high school. Six participants taught non-core subject courses for elementary and/or high school students, with the remaining bulk of participants representing an evenly distributed range of subjects, including Spanish, social studies, mathematics, science, or a mixture, across undergraduate, graduate, and professional and/or adult education contexts. In addition, 16 of these participants teaching in higher-education contexts were also teaching high school students.

3.2. Prior and In-Service ESD Training

Twenty-two of the 42 participants reported having received training about or information related to ESD and its principles and processes during their university studies or as part of their teacher certification program. Twenty participants reported that they had never received such training or information during their university studies or through their teacher certification program. Twenty-two participants reported having received training or having participated in workshops on ESD as in-service teachers, while 20 reported never having received in-service support.

3.3. ESD Integration

The highest reported frequency of integration for each sustainability issue was *frequently* (several times within an academic period). Fourteen participants reported that they *frequently* addressed environmental issues in class; 15 reported the same for social issues; and 18 reported a frequent integration of economic issues. The second most reported frequency of integration for environmental issues was *very frequently* (11 responses), followed by *always* (eight) and *sometimes* (eight). For social issues, the most frequently selected responses of integration reported were *very frequently* (10 responses), followed by *always* (10). For economic issues, the most frequently selected response was *very frequently* (seven responses) and *always* (seven). Contrastingly, only one participant reported *never* integrating environmental issues, two reported *never* doing so for social issues, and only three reported the same for economic issues.

3.4. Sustainability Concerns

3.4.1. Environmental Sustainability Concerns

In total, 24 different environmental issues were reported by the 42 participants. Several participants reported more than the two environmental issues requested; as such, the total number of tabulated comments across all environmental issues was 92. The reported issues evenly cited across the representative countries converged the most on deforestation (21 out of 92 comments), follow ed by trash management (16 out of 92), and pollution of freshwater sources (9 out of 92). Guatemalan participants most frequently reported nationwide deforestation as a worrisome environmental issue (12 out of 47 comments), which was the same as for the Nicaraguan teachers (9 out of 29). As for the Costa Rican teachers, trash management and trash pollution were the most frequently mentioned (4 out of 16), but they demonstrated a relatively even distribution of reported concerns.

3.4.2. Social Sustainability Concerns

In total, 31 different social issues were reported by the 42 participants, with 87 tabulated answers across all the reported social issues. Across all three countries, the lack of employment opportunities was reported the most (8 out of 87), followed by violence against women and/or children (intrafamily violence) (7 out of 87), followed by femicides (murders against women committed by partner/spouse), as well as insecurity and violence (6 responses out of 87). Guatemalan participants reported insecurity and violence the most (6 out of 43), while femicides were the most frequently mentioned by Nicaraguan teachers (5 out of 27). Lack of employment opportunities was the social issue reported the most by Costa Rican teachers (3 out of 17).

3.4.3. Economic Sustainability Concerns

In total, 31 different economic issues were reported by the 42 participants, with 89 total instantiations all reporting economic issues. Across all three countries, the lack of employment opportunities was the economic issue reported as the most concerning (28 out of 89), follow ed by low or unjust salaries and high costs of living (11 out of 89) and the COVID-19 crisis (six out of 89). Lack of employment opportunities was the most frequently mentioned economic issue by Guatemalan teachers (15 out of 44 answers) as well as by the Nicaraguan teachers (10 out of 25). The Costa Rican teachers demonstrated broad concern for 15 economic issues (e.g., improper use of financial resources destined for community development; fiscal crisis and elevated taxes in comparison to salaries; and lack of support to small-scale producers and to entrepreneurs), with no attention to one particular topic over another.

3.5. Views on and Understandings of ESD (ESD Definition)

Following the guidelines of grounded theory, the inductive coding of constructed definitions of ESD (number 16, *describe in your own words education for sustainable development*) led to the production of the 42 first-level codes and 5 higher-level codes detailed in Figure 1.

The analysis between the higher-level codes and Tilbury's [16] ESD learning processes and strategies (ESD principles) confirmed that the participants' responses about what their understanding of ESD contained are congruent with the stated principles, although the responses did not capture the entirety of these. In order to illustrate these findings, consider the higher-level code *Sustainable uses of natural resources and environments*. This thematic marker includes first-level codes relating to the common message of development for the conservation and preservation of natural resources and environments for current and future generations, a key goal that partially reflects the ESD process and learning principles. The higher-level code *Sustainability oriented behaviors and ways of thinking* captured the first-level codes associated with behaving, thinking, and/or acting in ways that are environmentally friendly and that include awareness of the impact of personal actions. In addition, the higher-level code *Innovations for sustainability* includes first-level codes that captured messages pertaining to innovation as a key tool for generating solutions to

different sustainability issues. Finally, the higher-level code *Integrated curricula and learning* captured first-level codes that emerged from responses about ESD as a type of education that involves non-standardized or alternative teaching approaches and resources designed to foster critical understanding about and active engagement in addressing sustainability issues. Such responses about ESD teaching highlight one key component of teaching under ESD, which is that learning about and for sustainability should be weaved into the instruction of all subjects [17].

While alignment between the participant responses and the ESD principles was observed, none of the responses reflected two key components from the ESD *process of collaboration and dialogue*: building partnerships across social sectors in order to collaborate with and learn from each other and cooperation with governmental institutions or departments [16]. In addition, none of the answers was congruent with, or directly mentioned a crucial message in, the ESD process of *engaging the whole system*; this principle highlights the importance of allowing schools to work with governing bodies, including teacher education programs, to bring about needed transformations related to the various forms of sustainability.

4. Discussion

4.1. Integration of and Knowledge about Sustainability Issues

Participants in this study reported a high frequency of integration of sustainability issues during core and non-core subject lessons. Furthermore, the 14 participants that did not receive any training or exposure to ESD during their pre-service and in-service years reported that they integrated all three kinds of sustainability issues frequently, very frequently, or always. If nearly half of the participants never received formal training on ESD as pre-service teachers or as in-service teachers, why was there such a high number of reports of the integration of sustainability issues into the daily teaching?

The reported responses to the questions about environmental, social, and economic concerns provide useful insights into the reported efforts at integration. Except for one respondent who mentioned *expansión del comunismo* (expansion of communism) as an economic concern, all the reported sustainability issues are indeed extraordinary and have measurable devastating effects on each country's human and other natural populations. Consider the environmental issues reported most frequently across all three countries: deforestation, followed by trash management and trash pollution, and pollution of rivers/freshwater bodies. The realities and ways of living for many Central American communities are dire; residents in all three countries face neglect by local and central governments and depend on unpolluted rivers and forests to live. Lack of employment opportunities and violence against women and/or children were the social concerns reported most frequently across all three countries, follow ed by femicides and insecurity/violence. To provide a glimpse of the severity of such reported social issues, during 2019 in Latin America, 4640 women were murdered by their partners [18]. Insecurity and violence have been part of the realities of Guatemalans and Nicaraguans for many decades now; political instability, violation of human rights, and limited options for employment dominate everyday life.

Furthermore, the lack of employment opportunities throughout Central America is a catalyst for criminal activities, drug consumption, and forced migration.

It can be concluded that regardless of the country and the mastery of the ESD processes and strategies, the reported high integration of sustainability concerns is motivated by the participants' lived experiences. Whether the participants come from urban or rural areas, they all belong to countries where social, environmental, and economic issues have severe, long-term effects on people's lives. A natural consequence of experiencing such realities for participating teachers is the desire to take action in any way possible, including addressing sustainability concerns in their classrooms. Findings from related studies suggest that one obstacle experienced by teachers from around the globe is their low confidence in their knowledge of sustainability issues [12,13]. For the case of the recruited teachers, their

knowledge of sustainability issues was vast, as their expanded answers demonstrated. Many participants reported more than the requested number of sustainability issues, included details about the causes of the reported issues, and their answers were even charged with emotions such as frustration, anger, and feelings of helplessness, as excerpted below: *[L]a falta de trabajo y el olvido del gobierno por la clase social media baja y baja, es muy lamentablecomo saleel solo para una clasesocial y la otra partesequeda por completo en el olvido, dando pie a la deliciencia en masa . . . el sinsabor de la poca ayuda no tiene otro sabor a desesperación* . . . [the lack of work and government's neglect of the middle low and low classes, it is very lamentable how the sun rises for one social class and the other one remains in complete obscurity, causing mass delinquency . . . the distaste of the limited help only tastes like desperation . . .].

Equally important is the need to question to what extent the reported integration is achieving a key learning goal in ESD—learning for sustainability. Are the lessons from the participants merely exposing students to sustainability issues or are they also introducing efforts, programs, projects, and individuals that are in the forefront of efforts to address local and global sustainability problems? Findings from this study also suggest the need for follow-up research that can provide insights into the integrated lessons produced by the teachers and how such efforts reflect ESD learning strategies such as innovative, systemic, and critical thinking [16]. Future iterations of this project will involve a greater number of participants and include other Central American countries that enable a broader exploration of patterns in respective perspectives and experiences.

4.2. Participants' Understandings and Views of ESD

The internationally reported challenges experienced by teachers when integrating sustainability issues suggests an immediate need to clarify and address the gap in teacher knowledge related to the key mechanisms, processes, and tools associated with ESD. The design and implementation of an *effective* ESD teacher training program should consider what teachers understand and know about ESD. As such, the data from this study provide an important starting point for future research aimed at supporting efforts for advancing ESD training for teachers in Central America. The process of coding participant responses helped to clarify the perspectives of our participants about ESD. While individual answers on the understanding of ESD did not detail every principle reported by Tilbury (2011), all 42 participants, regardless of their level of mastery or exposure to the field, answered with a message that aligned with at least one of these principles. This observation indicates that participants have some level of informed perceptions about ESD. That stated, all Central American educators must receive proper training on the learning processes, teaching strategies, design tools, and mechanisms to adopt and deliver an education fully shaped by the principles of ESD. An example of this need is evidenced in the recent first annual ESD and EE-related conference for Central American schools and educators. The first author of this study supported the organization of this event. A recurrent message she noted from conference participants was the interest and efforts for becoming more knowledgeable in ESD due to the severe conditions experienced in their communities. Many of these individuals expressed a lack of support or approval from respective supervisors for teaching about sustainability issues. Such reports run counter to the widely held sentiment recently voiced by Germany's Chancellor Angela Merkel: "We need training for sustainable development not to be a privilege but accessible to all people. . . " [1]

A second key finding from this study was that none of the participants' responses reflected a crucial goal from two ESD learning processes—the *process of collaboration and dialogue* and the *process of engaging the whole system* [16]. As previously mentioned, this goal refers to needed collaborative support from governmental bodies and teaching education programs. Such fundamental partnerships might be impossible in countries experiencing political instability, corruption, and regulatory bodies resistant to progressive change in education. This finding raises the question, how can collaboration with such governing institutions be achieved in countries where those in power do not allow it? What processes

and strategies need to be added to the UNESCO ESD report [16] that will support teachers who live in countries governed by systems resistant to transformation?

While the embracing of ESD by teachers is key for achieving a nationwide adoption of its processes and principles, those in charge of deciding what is included in teacher education programs in Central American countries represent one of the biggest barriers to nationwide adoption of ESD. Further research is needed on the academic performance and social and environmental engagement of Central American students learning at schools where ESD processes are fully acknowledged and enacted. Such research may be helpful in loosening the authoritative grip that governmental leaders in Central American countries have on school policies and training programs that preclude ESD education.

Hence, this study represents the initial phase of a larger effort to determine the most efficient pathways to bring ESD training to educators in Central America, regardless of the level of governmental support. The next phases of this study will include further exploration into the processes and mechanisms that are key for adopting ESD and the approaches for building a resilient framework that effectively withstands the political, social, cultural, and financial hardships facing Central Americans.

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Proceeding Paper

Connecting Positive Peace and Positive Health in a Systems Approach to Sustainable Development at the Community Level †

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Abstract: The 2030 Agenda for Sustainable Development recognized the interconnectedness of sustainable development, with peace and health emerging as highly influential. Challenges to peace and health have been linked from a systems approach by existing research; however, the potential for positive peace and positive health to be connected in a self-sustaining system has been investigated with less rigor. The present research argues that recentering a systems approach on capacities rather than challenges at the community level may present useful opportunities to both understand and pursue sustainability, which this paper explores through the lens of peace (SDG 16) and health (SDG 3).

Keywords: assets; armed conflict; capacities; community agency; collective violence; disease; localization agenda; salutogenesis; sustainable development; systems approaches

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1. Introduction

The Sustainable Development Goals are designed in appreciation of their interlinkages, and understanding these connections may facilitate progress toward their achievement [1,2]. Systems thinking has been embraced as a potentially more effective approach to address complex challenges to sustainable development, such as building peace and cultivating health. Recentering a systems approach at the local level, even for large-scale challenges such as these, may present useful opportunities to both develop and pursue sustainable development strategies in more integrated, locally meaningful, and ultimately more self-sustaining ways.

Tremendous global spending is dedicated to challenges related to peace and health (SDGs 16 and 3, respectively), collectively amounting to some 20% of global GDP each year [3,4], but neither amount of spending nor using GDP as a metric necessarily gives useful results. Despite these investments, the global community has struggled to make progress in addressing large-scale collective violence—such as war, criminal violence, and genocide—and disease/injury/bodily harm—such as pandemics, malnutrition and undernutrition, and communicable and noncommunicable diseases. This is all the more troubling, given that the "peace" and "health" SDGs both represent input and output into the 2030 Agenda; peace and health are fundamental to achieving all of the SDGs, and, at the same time, they are highly dependent on having achieved the SDGs.

Critiques of global development initiatives such as the SDGs argue that these collective failures are due to the persistence of a global hegemony of top-down power, opaque and

exclusive decision-making structures, and the pursuit of unfettered economic growth over human and environmental sustainability. In response, the "localization agenda" has gained momentum to decentralize resources and power in international humanitarian and development work to local actors, who are seen as better positioned to leverage their knowledge, skills, and capacities to improve actual conditions in their own localities. While communities are notoriously challenging and problematic to define due to their dynamism, diversity, and subjectivity, they may be "linked by common interests and conditions, becoming effective and successful agents of change" [5] when addressing the complex challenges that affect them, including those related to peace and health.

Challenges to peace and health have also been linked together in self-reinforcing systems of collective violence and disease/injury/bodily harm. However, little work to date has sought to develop and link positive conceptualizations of peace and health in self-reinforcing systems, especially at the community level. This paper contends that a reorientation away from challenges and toward capacities for peace and health at the community level may unlock insights into a new vision for how to translate a systems approach to sustainable development into action, with implications for the post-2030 agenda.

2. Deepening Understandings of Peace and Health

Peace and health are conventionally conceptualized in relation to their shadows of violence and disease/injury/bodily harm, and contemporary inquiry is dominated by investigations and interventions related to violence [6] and disease/injury/bodily harm [7]. Yet, the absence of violence and disease/injury/bodily harm do not fully encapsulate the true meanings of peace and health, which are known to be more holistic, nuanced, and thus, challenging to define.

Negative peace refers to the absence of direct violence, such as the absence or cessation of warfare. Positive peace expands to include "the absence/reduction of violence of all kinds," including structural and cultural forms of violence, and "nonviolent and creative conflict transformation" [8] (p. 9). Positive peace encompasses "the attitudes, institutions and structures that create and sustain peaceful societies" [3] (p. 3). Conflict is an inherent part of all societies, and positive peace enables nonviolent and constructive ways of addressing conflict.

Peace has been explored by numerous cultures around the world, including concepts such as:

> "*ahimsa* (Indian; to kill no living creature), *shanti* (Indian; to maintain a tranquil mindset even in suffering or conflict), *heiwa* (Japanese; aligning oneself to the common good/social order), *al-Islam* (Arabic; to be at peace in alignment with the will of Allah), *eirene* (Greek; prosperity and order), and *shalom* (Hebrew; right relationships or unity and prosperity in alignment with the will of Jehovah).
>
> (Ishida, 1969 as cited in [9])

Despite the different perspectives on peace, these concepts may share certain features in common. In review of the world's most peaceful countries, the Institute for Economics and Peace (IEP) [3] identifies eight pillars that constitute positive peace, as follows:

- Well-functioning government;
- Sound business environment;
- Equitable distribution of resources;
- Acceptance of the rights of others;
- Good relations with neighbors;
- Free flow of information;
- High levels of human capital;
- Low levels of corruption.

Certain aspects of peace may appear universal, but peace is an inherently contested concept [9] that shifts across place and time and may itself be a source of conflict [10]. At a community level, peace may take on more practical dimensions that are highly contex-

tualized, and it may manifest in everyday ways such as people being able to send their children to school [11]. These community-level understandings may provide insights into the local values and assets that provide the building blocks for peace from the ground up.

Conceptualizations of health are similarly rich and pluralistic, despite the field of public health often adopting a biomedical understanding of health as the absence of disease and functioning at a "normal" level [12]. Recognizing the multifaceted nature of health, the World Health Organization [13] defined health as, "A state of complete physical, mental and social wellbeing and not merely the absence of disease or infirmity." Building on this touchstone of global understanding, positive health includes characteristics that may increase wellbeing, longevity, and the ability to recover from health challenges [14]. Positive health refers to "A spectrum of wellbeing and flourishing partially independent from disease or infirmity that is determined by a collection of health assets" [5] (p. 2).

Various cultures around the world have developed conceptualizations of health that provide deeper insights into positive health. For example, Aboriginal and Torres Strait Islander culture in Australia identifies facets of health that include physical, mental, cultural and spiritual, environmental, and place-based factors [15]. Andean culture developed the concept of Buen Vivir, which highlights the centrality of social and environmental harmony in collective wellbeing [16]. These definitions suggest that complete health encompasses the presence of positive assets for health that align with cultural and social values [17], which implies that "positive health" is normatively defined [18,19] by a specific collective in a specific context. As such, positive health may evade standardization, as communities pursue their health goals with a unique collection of assets in ways that align with local values. Health cannot be reduced to biological and behavioral factors, but it is socially determined through structures of power [20]. More equitable distributions of power and resources are seen as central to enhancing both negative and positive health.

The 2030 Agenda matured how it represented peace and health as SDGs from how they were addressed in the Millennium Development Goals (MDGs). While peace was arguably implicit in the MDGs, it became an explicit standalone goal in the SDGs. SDG 16 on peace aims to "promote peaceful and inclusive societies for sustainable development, provide access to justice for all and build effective, accountable and inclusive institutions at all levels." The MDGs sought to address a specific and narrow range of health concerns, such as malaria, that were seen as relevant to low- and middle-income countries, but the SDGs reconfigured their focus on health issues more universally. SDG 3 on health aims to "ensure healthy lives and promote wellbeing for all at all ages." While these ambitious standalone goals are written in ways that reflect positive conceptualizations of peace and health, they do not reflect diverse learnings related to positive peace and positive health concepts and practices. SDG 16 on peace has been heavily critiqued for its targets and indicators, representing a technocratic rather than nuanced understanding of peace [21] and not addressing issues that bear on the attainment of peace such as sustainable environmental governance [22]. SDG 3 on health targets and indicators predominantly focus on ameliorating diseases and premature mortality (i.e., achieving negative health population benchmarks) and do not include positive health assets. Neither SDG lends itself to bolstering grassroots community efforts in building locally meaningful peace and health.

3. Connecting Positive Peace and Positive Health through Systems Thinking at the Community Level

Given the globally pervasive and entrenched challenges related to collective violence and disease/injury/bodily harm, is there utility in expanding focus to an even greater range of concerns through the lens of positive peace and positive health? A negative prism brings focus to interlocking challenges, but it does little to illuminate integrated solutions for social–environmental thriving. Positive peace and positive health may be best described as self-generative processes rather than static conditions: the structures and the effects of positive peace and positive health support the sustainable growth of peace and health in a virtuous cycle. A narrow focus on challenges alone does little to ameliorate underlying

structures and even less to build structures that support alternative futures. The flip side of a problem-based system may not be its opposite, but it may represent a new system entirely. Therefore, the tools to envisage and build such sustainable futures may be derived from sources beyond the dominant global perspective.

Daily collective actions and aspirations play out at the community level, which may be disconnected from central systems of governance and power where most formal peace and health strategies are developed and disseminated. Communities often know their challenges as well as their strengths, guided by their values and visions for the future. While the notion of community is contested, we conceptualize it as being defined by identities, processes, and decision-making structures that are located in a socially meaningful unit. The community level enables focus on issues and actions not bound by state-level politics, which currently dominates the SDGs. Indeed, a community-level focus rather than individual- or global-level ones may resonate more closely with collectivist cultures around the world, comprising approximately 70% of the global population. In this way, a focus on the community level highlights the need for cooperative action within communities as well as between actors at multiple institutional scales (e.g., local, state, international).

A reorientation toward positive peace and positive health in communities also uncovers extant resources and values within and between communities worldwide. For the majority of the world's population—located at a distance from formalized systems of power and decision making—incentives to nurture conditions for positive peace and positive health are constrained by a deficit model of health and development. Insights derived from the community level highlight the interplay between agency and structure and community ability to leverage agency to pressure structural changes through organized action and advocacy. In contrast to a deficit model, asset-based approaches encourage collective discovery of skills, resources, and capacities inherent in communities in order to facilitate home-grown solutions to peace, health, and other development challenges.

To uncover and mobilize resources to collectively build structures supporting positive health and peace, a systems-based approach may be helpful. From the local perspective, what matters most for peace and health cannot be distilled into neatly defined issues and may not even be explicitly labelled as peace and health issues. Grappling with complexity and interconnectivity are unavoidable when taking a community perspective. Insights from civil society organizations worldwide highlight the collision of factors shaping livelihoods and wellbeing, including increasing social inequities, a globalized extractive economy, unsustainable food systems, climate change, and corruption. Systems thinking enables grappling with complexity, embracing it as a part of life rather than resisting or abstracting problems into component parts. Through a systems approach, meaningful community outcomes may be thought of as a product of a complex set of resources, events, and activities operating in a nonlinear and interlinked manner. Various perspectives can also be accounted for: not only can the unique perspective of each actor in the system be recognized, collective goals of peace and health can also be positioned in relation to broader systems. The way in which resources interact, as well as the quality of these interactions and overall direction of the system, provides clues as to levers for interventions and insights about ideal conditions for human flourishing.

4. Developing a Positive Peace and Positive Health System

The violence–disease/injury/bodily harm nexus has been explored in academic scholarship and global policy spheres, with violence and disease/injury/bodily harm recognized as driving each other. Violence, including collective violence, is a recognized public health threat [23]. Armed conflicts are a significant determinant of global health [24] due to actors in armed conflicts directly causing injury and death and implementing strategies of war including famine [25]. As collective violence increases, so does the incidence of infectious disease transmission and outbreak [26]. Violent conflicts also indirectly increase the incidence of disease/injury/bodily harm and other negative health outcomes through

detrimental impacts on infrastructure, including structures related to water, sanitation, and health (WASH), and diverted resources toward war-related activities, for example.

Disease has also been linked to increased violent conflict onset by way of the parasite–stress theory of intrastate conflict: a high intensity of infectious disease may contribute to inter-group hostility and group fissioning, which has a direct causal influence on the onset of small-scale intrastate armed conflicts [26]. Ide [27] found that the COVID-19 pandemic has affected armed conflict dynamics in ways that often resulted in escalation, though de-escalation of armed conflict has occurred in some cases.

Violence and disease/injury/bodily harm are connected in a system not only because they are causally linked directly and indirectly in both directions, but also because they share common drivers which they also produce (see Figure 1). Inequities and socially and environmentally unsustainable patterns of development are linked to both violence and disease/injury/bodily harm, and may manifest as a host of engrained difficulties, including but not limited to environmental degradation and destruction, disasters including those influenced by climate change, food and water insecurity, lack of dignified livelihoods, lack of education, oppression, marginalization, poverty, and inequitable resource distribution and access to services. Complex interactions between violence, disease/injury/bodily harm, and these related issues make this problem-centric system particularly wicked, since it is constantly reproducing and reinforcing itself and resists solutions. For example, environmental destruction and a lack of dignified livelihoods will produce a constant stream of challenges to peace and health, and addressing specific diseases or violent conflicts will do little to change the complex sources of these challenges. A negative orientation with a narrow focus on challenges may not be able to recognize community assets and capacities and generate actions that affect a system of positive peace and positive health.

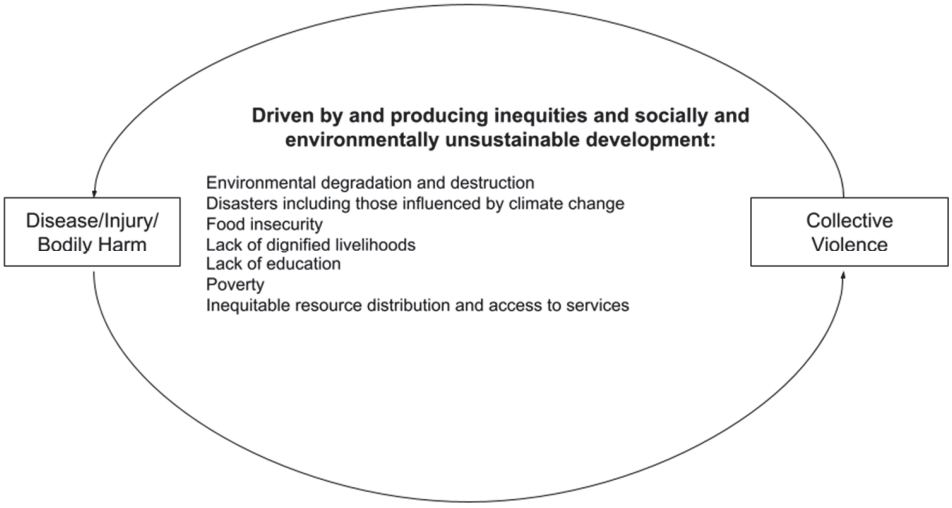

Figure 1. Collective violence and disease/injury/bodily harm are connected in a system with direct connections as well as through structural drivers that are also produced by the system.

Positive peace and positive health may be connected in a self-sustaining system that is also linked to sustainable development more broadly, but the positive peace–health nexus has been investigated with far less rigor. Recent research has posited that the global health community may contribute to conflict prevention and peacebuilding through addressing the structural and situational roots of conflict [24], including how health initiatives that address disease outbreaks (or attempt to prevent disease outbreaks through vaccination programs) may lead to humanitarian ceasefires or the cessation of violence. However, this still amounts to negative health interventions leading to negative peace, and evidence for this kind of health diplomacy is lacking [28]. This area of research does not comment on how building positive health (including its diverse features) may contribute to positive peace, and, likewise, how positive peace (including its diverse features) may in turn build

positive health beyond the absence of disease/injury/bodily harm, without disability as a detriment (see Figure 2).

Figure 2. Positive peace and positive health are connected in a system with direct connections as well as through structural drivers that are also produced by the system.

Notions of positive peace and positive health encompass the presence of positive features that overlap conceptually. For example, positive peace and positive health share local and place-based understandings and processes related to social interconnectedness, living in harmony with the natural environment, and the freedom to live in accordance with shared values. Moreover, positive peace and positive health may be interdependent and lend themselves to encompassing and supporting other SDGs, such as reducing inequalities (SDGs 5 and 10) and using environmental resources sustainably (SDGs 6, 12, 13 and 15). These overlaps have been increasingly recognized by the international community, and the WHO [29] (p. 3) went so far as to claim, "Investing in health is investing in peace." Positive peace and positive health are also recognized as input and output into sustainable development. For example, United Nations Secretary-General Ban Ki-moon stated that "peaceful and inclusive societies are both outcomes and enablers of sustainable development" [30] (p. 1).

Communities have the ability to exercise agency—setting their own agendas, building and mobilizing their own resources and assets, and influencing their life circumstances according to their values—not only in the absence of challenges and constraints. Both positive peace and positive health connote the presence of processes leading to social integration, cooperation, and harmony, which contribute to the ability of communities to self-organize and take action in the face of the complex social–environmental challenges that face them. Collective violence and disease/injury/bodily harm may also be opportunities for communities to strengthen their collective goals and vision for alternative futures, as challenges necessitate that communities bring together their disparate assets and resources to function in an integrated way.

Agency-based approaches (i.e., those approaches that seek to support community agency and empowerment) to positive peace and positive health seek to recognize and identify, build and nurture, connect and reinforce, and mobilize and leverage community assets and capacities to enable sustainable development that aligns with local values and social meaning. Community resources and assets are unique to their social, cultural, political, economic, and environmental conditions, and a universal recipe for positive peace and positive health does not exist. However, it is through these agency-based processes that communities can strengthen themselves, with positive spillover effects on ameliorating collective violence and disease/injury/bodily harm, and their effects on community wellbeing and sustainable development more broadly. The existence of a

negative system cannot and should not be ignored, but a positive system exists alongside it that must be recognized and nurtured in order for it to become more dominant.

5. Implications for a Post-2030 Agenda and Conclusions

Because processes of social change to build peace and cultivate health are not politically neutral, community-level systems approaches may involve strengthening local abilities to renegotiate power relationships with the goal of redressing inequitable distributions of power and resources and exclusive decision-making processes, which are at the heart of unsustainable development. Communities are capable of championing positive changes leading to positive peace and positive health, but others—international, national, and private sectors—may play important support roles. For example, they may be able to provide certain targeted resources and support, help to remove structural barriers, lend wider legitimacy to grassroots efforts, and connect communities through translocal initiatives to create alternative agendas [5]. These local agendas may or may not line up neatly with global peace and health agendas, including the SDGs (16 and 3, and others in connection), or progress in linear ways that match with donor funding and reporting timelines.

As such, the key is promoting a more integrated agenda combining localization and positiveness in peace and health, with appropriate balances for translocal initiatives beyond localization, and developing community capacities even when they are not directly tied to challenges within this system (or set of systems drawing from formal and informal institutions, resources, and factors). This paper argues against lumping together positive and negative concepts of peace and health, as the SDGs do, with a particular focus on negative framings. This also means recognizing that any framing, including localization and positiveness, has limitations, so complements and supplements are required for balance. Too often, community approaches fall prey to romanticization of the local and fetishizing traditional or vernacular preferences. Nor should this be an excuse for larger-scale interests to dominate or dictate. Partnerships between the local and the international (encompassing institutional scales in between) must build on long-term, sustained dialogue to develop progressive agendas together, pointing to the need for investments to focus on creating and mediating channels for communication first and foremost.

Ultimately, a constructive agenda is sought to advance peace and health for the 2030 and post-2030 agendas as a continuum. Focusing on top-down targets and indicators can lead to subservience toward allegedly universal numbers rather than recognizing nuances, provisos, and contextualities—even if universality is not a baseline intention of the SDGs. Starting from the ground up may better capture how positive peace and positive health actually manifest and interact in people's daily lives, including the challenges that they face and the strategies they find most relevant to pursuing collective thriving. Global expertise and thinking should supplement—and not drive—pathways forward. This requires embarking on a new agenda to (1) explore the evolving embodied and expressed meanings of positive peace and positive health in localities around the world, (2) identify local strategies to pursue positive peace and positive health goals, and (3) iteratively assess what is needed to advance constructive local strategies. Connections between the local, state, and international levels can be leveraged to offer insights from other contexts as well as to safeguard against harmful local strategies that perpetuate exclusion and domination, particularly of marginalized groups.

The SDGs already involve self-monitoring and self-reporting, which introduces the difficulty of independent monitoring and constructive critique within an international system that is intended to effect change at local levels. This reiterates the long-standing question of how to design a framework that is dynamic, flexible, agile, and constructively critiquing for the 2030-plus-post-2030 agenda, with traction at the community level. States and other governments may not be best positioned to gather the needed input or report progress, and participatory approaches may seek to build coalitions centering on and connecting local formal and informal peace and health systems, including community peacebuilders, healthcare workers, and other active stakeholders. Targets and indicators

more broadly applicable may be derived from this grounded approach and applied at the international level to ensure that no one is left behind, not only in making progress in negative peace and negative health, but also in building local futures steeped in positive peace and positive health.

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Proceeding Paper

A Comparative Analysis of the Role of the Youth in Localizing SDG 11 at the Local Level in the Global North and Global South †

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Abstract: This paper analyzes the gaps in opportunities for the youth between the global north and the global south for the achievement of Sustainable Development Goal 11 (SDG11) and the challenges they encounter in their journey to support this goal. Data gathered from the Local Pathways Fellowship (LPF) program application and members distribution are studied in this paper and inform us about the demand for urban planning knowledge in these two regions. Additionally, this paper analyzes a conducted interactive exercise where youth from 24 different cities come together to analyze one of the targets from SDG11 and reimagine how cities can achieve SDG11 by 2030. This exercise helps us understand how the youth re-imagine their own social world and notably their urban spaces in times of crisis. Additionally, following the above pattern, this paper answers the following research question: Given the presumptions that youth in the global north have access to more opportunities than young people from the global south, one should ask: to what extent can we observe that young people globally, regardless of their city of residence, share common obstacles and opportunities when implementing SDG 11-related projects?

Keywords: urban; SDG 11; sustainable cities; youth; urban; global north; global south; cities

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1. Introduction

Despite their unfavorable position in the hierarchies of power, young people play a major role in the processes of change taking place in urban spaces [1]. (For sources on the marginalization of youth, check [1]). This social group, which is considered precarious, seems then to constitute an effective tool for analysis of politics and of the relations of contestation and domination, and most importantly, of development and change. Youth as a scientific object has been studied through the prisms of international organizations and think tanks that employ the logic of "empowerment". This logic of empowering young people in most cases has not taken into account the societal configurations of the states from which they come. Therefore, a comparative meso-sociological study that conforms with the theoretical framework of the political sociology of the youth and the political sociology of public actions is needed.

The youth have little influence on the policymaking process as to how their cities are planned and organized. Therefore, the cross-generational aspect of integrating the youth in the policymaking process ensures a sense of belonging and continuity in cities [2]. SDSN Youth is one of the world's biggest networks of young leaders working to accelerate solutions towards the Sustainable Development Goals. Its mission is to mobilize youth to shape a sustainable world for future generations. Founded in 2015, the network has expanded rapidly, with 750+ member organizations spreading across 127 countries and

four different programs on innovation and entrepreneurship, education, and sustainable cities that have reached 2600 members. It places young people at the forefront of achieving the SDGs.

The Local Pathways Fellowship is one of the four flagship programs by SDSN Youth. The LPF is a 10-month practically oriented training program, designed to enable young fellows to understand the process of localizing SDG 11 at the local level. Through the program fellows analyse the context of their cities and to then develop solutions to their local challenges from ideation to execution.

SDG11 is "Make cities inclusive, safe, resilient and sustainable". It has 10 targets to be achieved, and this is being measured with 15 indicators. These targets include work in mobility, housing, waste management, green public spaces, and participatory and inclusive planning [3].

When it comes to SDG11, the literature shows that by 2050, our cities will be home to 70% of the projected 9 billion people. Half of the world's population today is under the age of 30, with a large majority of them already living or aspiring to live in urban areas, leaving no doubt that the achievement or failure of the Sustainable Development Goals (SDGs) will be determined in cities and that the youth plays a crucial role in this [4]. Today's large cities are concentrated in the global south and 60% of the urban growth by 2050 will be taking place in this region [5].

Over the coming decades, urbanisation will be a defining trend in many parts of the world, especially in East Asia, South Asia, and sub-Saharan Africa, where the bulk of extreme poverty is concentrated [6].

This paper uses the Brandt Line visualization as shown in Figure 1 to describe what is referenced as the Global North and Global South.

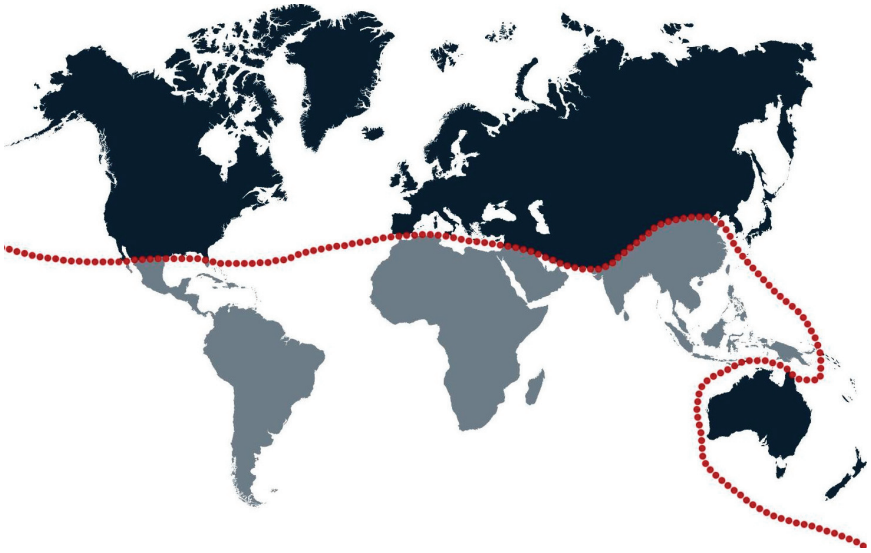


Figure 1. Brandt Line.

The 'Brandt Line' is a visualization created to illustrate international inequalities and the socioeconomic gulf that separates regions of the world, popularised in North–South: A Programme for Survival—also known as the Brandt report. Snaking across continents to divide the world into the richer North and the poorer Global South, the Brandt Line has for four decades been one of the most recognizable and influential ways of visualizing world politics as shown in Figure 1 [7].

2. Materials and Methods

This paper analyses data gathered through the LPF program through its application process, cohorts, and an interactive exercise with fellows.

2.1. Distribution of LPF's Applicants and Fellows

This section compiles the number of applications received by the LPF between 2018 and 2020 from the global south versus the ones received from the global north. It also showcases the number of fellows that were selected for the program from each region.

The LPF opens a call for applications every year for 6 weeks and invites youth between 18 and 30 who are interested in SDG11 to be part of the LPF. The call is marketed through the LPF's, SDSN Youth's, and SDSN's websites, social media channels, and newsletters. Additionally, the program´s partners and former fellows support spreading the word.

The application consists of completing two questionnaires. In the first one, fellows are asked to outline their motivation to become a Local Pathways Fellow, describe what makes them a good candidate to be an LPF fellow and how their background and experiences can help them become a successful SDG advocate in their city/community, and lastly talk about their vision and role for their city achieving SDG11 by 2030. The second questionnaire consists of submitting a writing sample and 3 videos one where they explain why they want to be part of the fellowship, a second one where they talk about an urban-related project they have participated in, and a last one where they analyse one of the sustainable development challenges that their city is facing and talk about possible solutions.

The selection process consists of a point-based system where fellows are rated based on their qualifications, experience, and proactivity. Secondary scoring criteria are geographical representation, volunteering experience, awareness of SDSN Youth´s mission, and knowledge of SDG11.

2.2. Interactive Exercise

This section consisted of an interactive exercise where 27 fellows were split into groups of 3–4 people. There were groups with all global north residents, others all global south residents, and groups that mixed both. The cities represented in this exercise were Abu Dhabi, Caracas, Celaya, Chennai, Dublin, Ensenada, Gurugram, Hong Kong, Islamabad, Istanbul, Johannesburg, Juba, Lucca, Marseille, Meanjin, Monterrey, Pune, San Pablo Sula, São Paulo, Toluca, Toronto, Warri, and Yantai.

Participants were asked to describe one of their regular commutes including as much detail as possible, such as descriptions of sidewalks, crosswalks, public transportation systems, bus stops, express lanes, toll systems, etc. Then, they were asked to choose one of the commutes from the group and reimagine how it could be better. They analysed and listed approaches that could be taken to improve the commute.

3. Results

3.1. Distribution of LPF's Applicants and Fellows

Table 1 shows a total of 2810 applications received between 2018 and 2021 where 2390 come from the global south (85%) and 430 from the global north (15%).

Table 1. Applications received from the global north vs. global south between 2018 and 2021to be part of the LPF program.

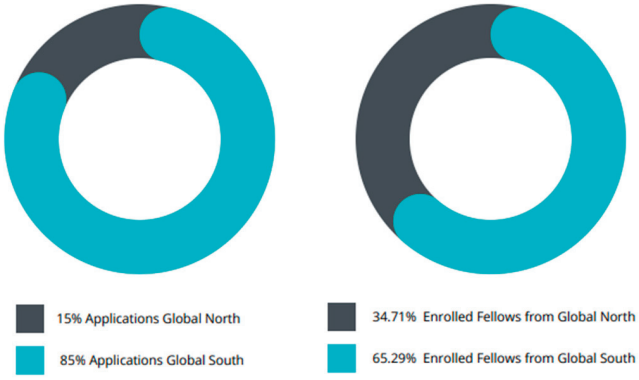
LPF Cohort	No. of Applications Received	% Applicants Global South	% Applicants Global North
2018	300	77%	23%
2019	330	86%	15%
2020	1191	86%	14%
2021	989	85%	15%

Table 2 shows a total of 363 fellows spanning across 4 cohorts, where 237 are from the global south (65.29%) and 126 are from the global north (34.71%).

Table 2. Fellows that were selected to be part of the LPF program from global north vs. global south between 2018 and 2021.

LPF Cohort	No. of Fellows	% Fellows Global South	% Fellows Global North
2018	63	57%	43%
2019	57	74%	26%
2020	138	65%	35%
2021	105	66%	34%

Applications received by the LPF between 2018 and 2021 show a distribution of 85% coming from the global south and 15% from global north (15%) as shown in Figure 2.



(**a**) (**b**)

Figure 2. (**a**) Applications received by the LPF between 2018 and 2021; (**b**) fellows selected to be part of the LPF program for the 2018–2021 cohorts.

3.2. Interactive Exercise

This exercise showed that all groups encountered some overlap in the issues that appear in mobility systems regardless of their location. Fellows from different regions mentioned similar problems, including lack of connectivity in public transit systems, and lack of safety for pedestrians and cyclists, and concluded that private vehicles were the safest and fastest mode of transportation. It was agreed that public transport can be improved in most cities and that there are numerous initiatives and much work to be done to achieve sustainable mobility in cities both in the GN and GS.

4. Discussion

This paper found that the LPF program received a much higher number of applications from the global south (85%) than from the global north (15%). This informs us that the demand for free online content and communities in topics related to SDG11 is much higher in the global south, which is where urban growth will ramp up in the coming years.

The ratio of selected fellows reveals 65.29% representation from the global south and 34.71% from the global north. This speaks to more qualified applicants coming from the global north.

5. Conclusions

Youth in the global north has more access to knowledge and content to SDG11-related topics. The number of applications received confirms this presumption by presenting a much higher number of applicants coming from the global south where offerings of this type of content are not as available. This enables the LPF program to capture more applicants from the GS. The number of selected fellows shows that applicants coming from the global north are more likely to secure a spot in the fellowship as they become more

informed about SDG11 content and are more likely to count on experience on urban-related projects.

It must be noted that the LPF is receiving this distribution of applications despite the fact that this program is offered in English, therefore limiting the applications coming from the GS to people who are bilingual. The demand coming from the GS would be even higher if the program were offered in languages native to this region. It can be questioned: To what extent can we observe that young people globally regardless of their city of residence share common obstacles and opportunities when implementing an SDG 11-related project?

Keeping this in mind, it is recommended that content produced around urban development best practices is made available in languages native to the GS in order to address the high demand for knowledge on this topic in this region.

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Proceeding Paper

Responding to Natural Disaster Emergencies as the Starting Point to Mainstream Climate Change-Sensitive Governance at Local Scale †

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Abstract: In 2018, the Autonomous Region of Friuli Venezia Giulia was affected by the violent Storm Vaia, which hit Italy in late October and early November. In response to the emergency situation, a commissioner was appointed by the Italian Government to manage post-emergency interventions. The Autonomous Region of Friuli Venezia Giulia set up a Support Office: an internal structure of the Civil Protection Department with the task of coordinating the post-emergency phase, organizing access to funds, strengthening synergies with local authorities, and raising awareness about the importance of implementing planning measures to reduce the risks resulting from climate change. One of the main tools for work and dialogue between stakeholders has been an online platform, the use of which has encouraged the spread of digitization, together with good practices, even in smaller municipalities, ensuring effective and constant monitoring and the transparency of procedures. Created to cope with an absolutely extraordinary condition and supported by tangible high-quality results, this system, designed to cope with exceptional events, has become a replicable model of administrative support to fragile areas.

Keywords: natural disaster; risk reduction; governance

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1. Introduction

Adverse natural phenomena have afflicted our territories with increasing frequency and intensity in recent decades due to climate change. Although efforts to establish synergies and share good practices to prevent irreversible damage are significant tools, an increasingly holistic approach has proven necessary to ensure the achievement of more organic and decisive results in supporting even the smallest local authorities dealing with complex territories, accompanying them in the adoption of cutting-edge governance measures. Individual measures can no longer be virtuous exceptions: they must be catalysts for a significant improvement in development planning and programming. Actions in response to natural disasters can be used as an opportunity to re-educate people about a more conscious land use and to reintroduce more forward-looking, sustainable and responsible habits into the system.

The violent Storm Vaia hit northern Italy between late October and early November 2018, strongly affecting Friuli Venezia Giulia (Figure 1). In order to respond to the Vaia emergency, the Italian Government invested in the region and appointed a delegated commissioner by order of the Head of the Civil Protection Department no. 558, on 15 November 2018. As envisaged in the order, the commissioner set up a new dedicated authority: the Commissioner's Support Office 558, an internal structure of the region's Civil Protection Department, with the task of managing the emergency funds allocated by

the Italian Government and the European Union for restoration and increased resilience in the areas affected by the calamitous events. Through the office, the region coordinated all the phases of the post-emergency action: it offered technical–administrative support and specific skills, and centralized the definition of a complex financial and bureaucratic procedure, thus relieving the municipalities and strengthening the already existing synergies [1].

Figure 1. Aerial view of one of the areas hit by Vaia in Friuli Venezia Giulia [2].

The "Vaia Model" in Friuli Venezia Giulia follows the rules of the Civil Protection Code and Order 558 which define exceptions to rules to speed up the use of allocated resources. However, certain aspects make it a unique and virtuous case, such as the establishment of an office created as a temporary response to an exceptional case that has become a permanent tool to combine action in the immediate aftermath of the disaster with multi-year planning aimed at a comprehensive vision regarding increased safety in the fragile areas of the region. The region is using Office 558 to the optimize skills and resources of the local authorities, following a training–action–preparation scheme: (1) by raising awareness on issues of climate adaptation, land use and development planning; (2) by guiding municipalities in accessing national and European funds that allow them to carry out the measures necessary to make the territory safe, guaranteeing assistance throughout the technical, administrative and financial processes; and (3) approving measures that, when necessary, make changes to the urban planning instrument, immediately strengthening the regulation of the territory and offering new references of good practices to be taken as an example for the future. The envisaged dual action of damage response and increasing resilience through legislative instruments and project interventions, combined with the overall vision, are drivers towards a new way of planning by integrating long-term prevention systems. The office is committed to distributing the funds in a transparent manner, ensuring an inclusive and fair distribution among the affected areas. The objectives achieved are the result of intertwined administrative levels. The municipalities of Upper Friuli, negatively affected by the under-population of the inland areas, rely on a limited number of staff, subject to heavy workloads, and suffer from more difficult access to services. The "Vaia Project" responds to both these critical issues by offering support and services. However, this is an exchange on equal footing: local authorities of the mountain areas bring specific knowledge of the territory and they have great experience in the implementation of prevention and mitigation works of hydrogeological risk in adverse contexts.

In the three years since Storm Vaia, the office has effectively committed EUR 379 million of public funds, carrying out 1108 land safety and resilience enhancements and enabling small mountain and inland communities to make the most of the resources made available. Some of the most significant projects include the reconstruction, in one year, of a bridge that had completely collapsed and was of strategic importance in connecting two valleys; the reclamation of a lake identified as necessary during a cleaning operation following the

storm (Figure 2); the positioning of a prefabricated foot, lowered from a helicopter at high altitude to restore the continuity of a pedestrian route; and the restoration of cultural assets in an archaeological area invaded by flooding during Storm Vaia, to ensure its conservation and return it to the public.

Figure 2. Aerial view of one of the areas hit by Vaia in Friuli Venezia Giulia [2].

The mission of Commissioner's Office 558 is to define a plan for the distribution of funds that meet, in a targeted manner, the specific needs of each territory for the remediation of damage caused by Vaia and to increase the resilience to exceptional weather events. This action is also aimed at consolidating awareness of the importance of implementing risk reduction measures in planning tools. These interventions are collected in a cloud platform: an official working tool where the RUPs (project managers) are called upon to make available the documentary dossier detailing, step-by-step, all the stages of the project process, from mapping to completion. This transparency enables comprehensive and effective monitoring and leaves room for investigation and analysis when necessary.

Created to cope with an absolutely extraordinary condition and supported by tangible high-quality results, bringing solutions to critical issues that could not be tackled before, this system has become a governance model to be applied to fragile areas of the territory. The establishment of Office 558, in support of the extraordinary commissioner of the local authorities responding to impending criticalities, is an opportunity to integrate climate change adaptation measures into spatial development and land use planning in adverse contexts.

2. Vaia: The Natural Disaster

At the end of October 2018, a pronounced North Atlantic pocket reached the Mediterranean. This atmospheric phenomenon rapidly increased in intensity, reaching exceptional characteristics with wind gusts of 100 to 200 km/h over a vast area of northern Italy, Switzerland, Austria and Slovenia, causing devastation and destroying thousands of hectares of Alpine forests. Although the power of the winds classifies it as a hurricane, this violent atmospheric event characterized by a strong Sirocco, heavy rainfall and exceptional storm surges is known by the two names of Storm Vaia and Storm Adrian. On 27 October, the rainfall, initially moderate, fell on the Julian Pre-Alps with accumulations that locally exceeded 100 mm, progressively increasing in the following days and reaching 300 mm, up to 900 mm between the Carnic Pre-Alps and Carnia (Figure 3). Similarly, the wind speed increased within twenty-four hours from 100 km/h to 180 km/h, reaching peaks of 200 km/h on Monte Rest, Malga Chiampiuz, at 1781 m above sea level (Figure 4) [3].

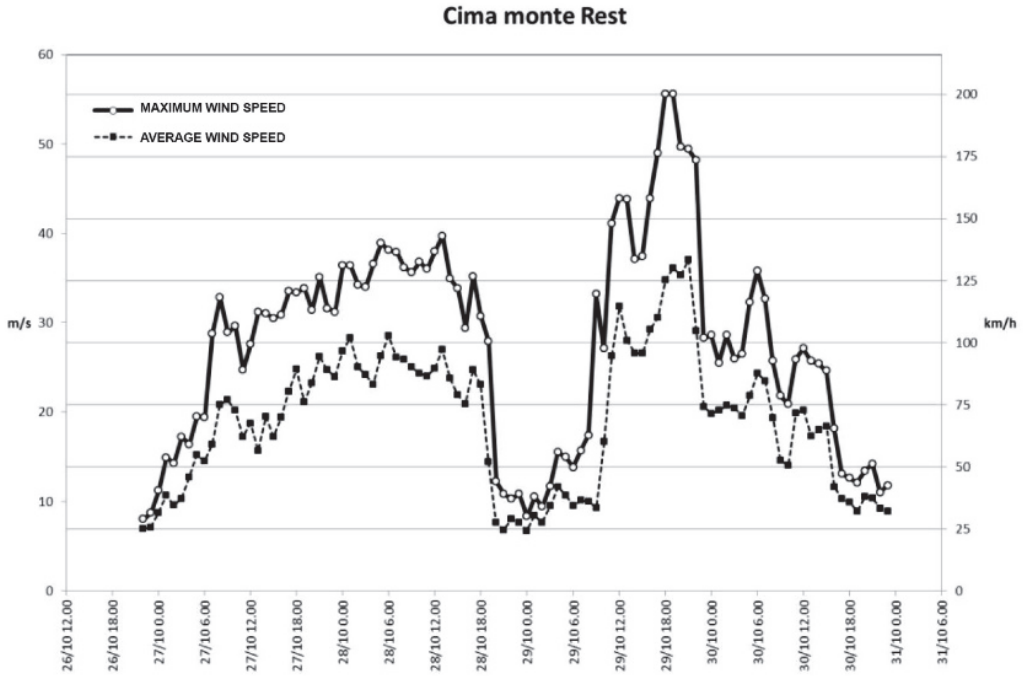

Figure 3. Diagram showing the rain-per-hour and the cumulative rainfall trends, measured at Malga Chiampiuz, between 27 October 2018 and 30 October 2018 [3].

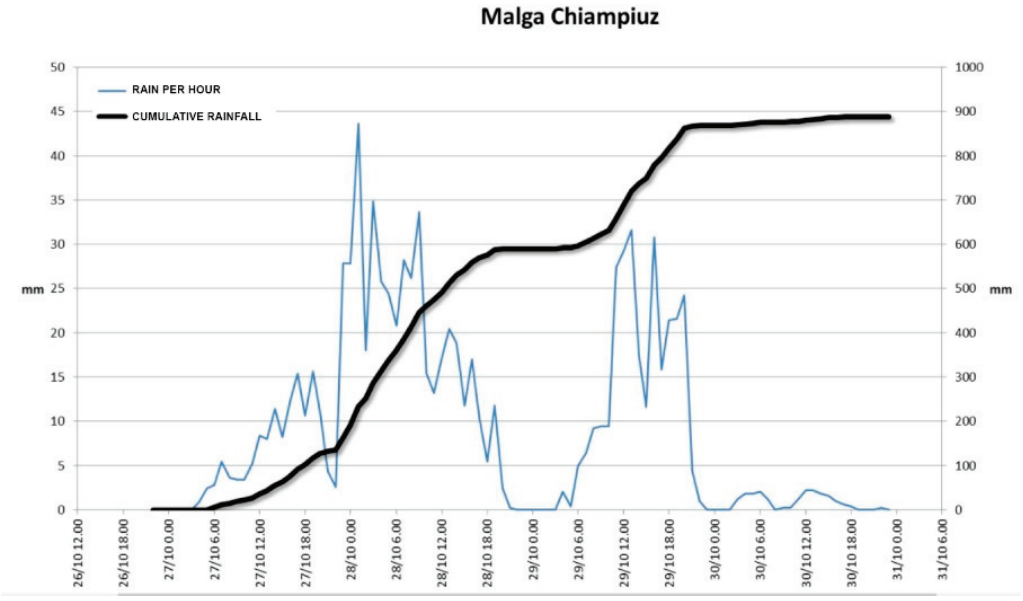

Figure 4. Diagram showing the maximum wind speed and the average wind speed, measured at Cima Monte Rest, between 27 October 2018 and 30 October 2018 [3].

The heavy rainfall had an impact on the flow of the water bodies, causing massive rises in river levels along their entire course which exceeded warning levels and reached exceptional flood peaks. The measured water levels, bank erosion, subsidence and solid transport confirm that this was a historic event. It did not only affect the Alps and the Pre-Alps, but all hilly and lowland areas that suffered damage from floods and inundations. The strong Sirocco and changes in atmospheric pressure intensified the strength of the natural phenomenon and influenced the tides, resulting in storm surges whose waves reached a height of 4 m. A tide of more than 1.2 m lasted for over six hours. The water

invaded the island of Grado and storm surges swept over the entire exposed coastline from Monfalcone to Lignano.

Vaia's undeniable severity was immediately recognized, leading the authorities to a prompt activation of the emergency response system.

3. An Integrated Response: Action at the Local Level and the National Plan

In order to deal with emergencies triggered by exceptional natural phenomena similar to Vaia, the Civil Protection Department established a plan of procedures for the alert, emergency and post-emergency phases. Action at the local level is guaranteed by teams of volunteers and specialized technicians who are called upon to implement the most effective damage control solutions to protect citizens in a very short time. In October 2018, the action on the ground saw the involvement of: 1137 volunteers in the mountain areas of Carnia and Pordenone, engaged in cutting down trees, restoring roads and emptying flooded houses; 1169 volunteers for monitoring the territory; 92 volunteers for the flood service, monitoring basins and watercourses; 30 operators to guarantee 24 h radio connection; and 11 officials for coordinating the transport of materials and vehicles as well as communication. The alert lasted 10 days and involved 181 municipal civil protection groups, 14 associations, and more than 700 vehicles and instruments. In view of the seriousness of the forecasts, the Civil Protection Department's emergency response specialists had already taken action in the pre-alert phase and begun to prepare the first preventive measures. In the operational phase of the alert, these were progressively implemented for a total of seventy emergency interventions to ensure safety. These grew in number as the events unfolded and the critical situation grew rapidly, collecting reports from the municipalities. The Autonomous Region of Friuli Venezia Giulia increased the amount of EUR 530,000 initially allocated [4], with an additional EUR 4 million, guaranteeing interventions in 27 municipal areas (Figure 5) [5].

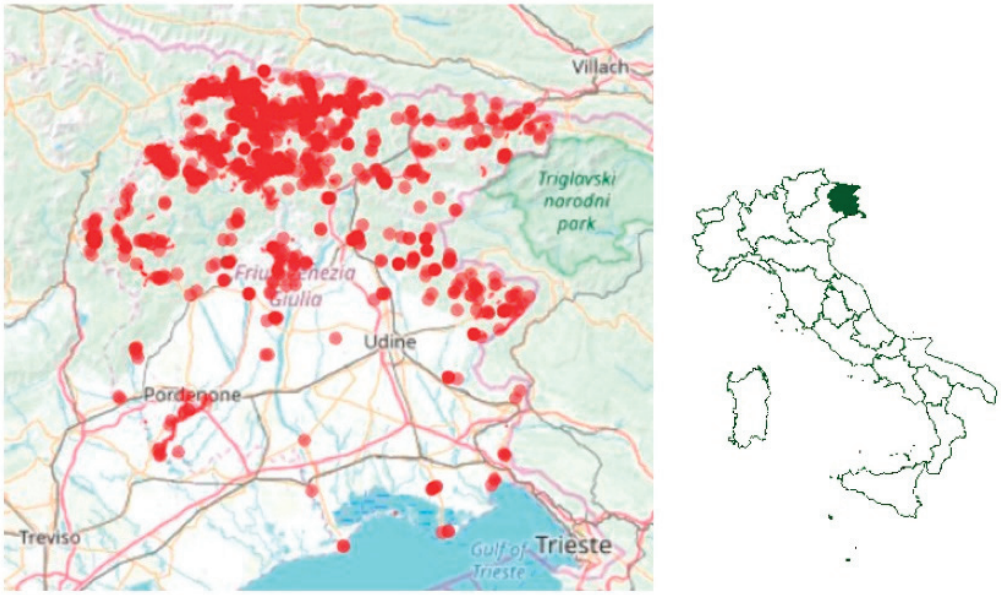

Figure 5. Diagram displaying the location of the major interventions between 2018 and 2021 [6].

All Italian regions affected by the natural disaster were asked to submit an economic estimate of the damage they had suffered. These reports formed the basis for the definition of a national plan. Thus, while at the local level the interventions provided immediate solutions to the most critical situations, at the national level an emergency management system was defined that was capable of responding to specific needs, offering solidity, and at the same time flexibility to adapt to the very different contexts affected by the disaster. The Italian government declared a State of Emergency on 8 November 2018 [7]. With Order no. 558, issued by the Council of Ministers on 15 November 2018, the President of the region

was appointed Delegated Commissioner for the management of the emergency in Friuli Venezia Giulia, invested with special powers to issue the necessary measures for the safety of the affected areas and to increase the resilience to events with similar characteristics to Vaia in the shortest possible time [8]. The following 20 December, the commissioner sent a survey of the damage with a request to the state of about EUR 560 million for 1138 interventions on public property and 356 on private property, such as family homes and the headquarters of local businesses and production activities (Figure 6). It was immediately clear that such a large number of works, distributed over a large part of the regional surface, required the involvement of all the administrations of the territory: the municipalities, the central directorates of the region, the chambers of commerce, the land reclamation consortia, the in-house companies of the region for the management and maintenance of regional roads and, more generally, all the subjects that manage strategic structures and infrastructure. Only by distributing the implementation of the works would it have been possible to proceed simultaneously and quickly, ensuring the rapid securing of the territory.

Figure 6. Aerial view of one of the areas hit by Vaia in Friuli Venezia Giulia [2].

For the management of civil protection emergencies, one of the instruments adopted by the state is to allow the Commissioner Delegate to open a special account at the Bank of Italy. This instrument allows funds to be made available and spent immediately and guarantees the transparency of financial transactions, which are carried out exclusively by means of Ministry of Economy and Finance software, called Geocos, which monitors payments and tracks flows in detail. It is a solution that allows the state to monitor the use of resources in a timely manner and the Delegated Commissioner to quickly direct payments without getting involved in the complex mechanisms of local public authority budgets. This system made it possible to overcome public finance constraints that would have led to longer periods of time being needed to commit resources, initiate procedures for awarding contracts, and make payments.

In the case of Vaia, the activation of the special accounting and the opening of a dedicated account at the Bank of Italy, the contents of which could not by law be allocated to other expenditures that did not have a causal link with the emergency, meant that the work of the Support Office never stopped and, consequently, that payments continued to be issued even during the crisis caused by the pandemic in recent years, to the benefit of local small businesses and professionals.

The resources allocated to the Autonomous Region of Friuli Venezia Giulia by the state were programmed over three years. Every year, from 2019 to 2021, by 31 January,

the National Department of Civil Protection was sent a Plan of Interventions that, by 31 December of the same year of programming, would be entrusted to companies to carry out the works. To date, 1108 interventions on public property have been programmed for a total amount of EUR 380 million, and about 10 million contributions have been granted to families and local businesses. Although the resources were mainly coming from the state, it is important to underline that the severity of the event also led the European Union Solidarity Fund to grant about EUR 277 million to Italy, of which the Autonomous Region of Friuli Venezia Giulia benefited about EUR 26 million [9].

The approach to the emergency followed a national strategy, but was built on the key principle of leaving organizational and management autonomy to the regions, which hold the specific knowledge of the territory, the needs, the criticalities, and the dynamics present at the local scale. The President of the Autonomous Region of Friuli Venezia Giulia, in his role as Delegated Commissioner, through the Support Office, chose to apply a system based on the centralization of administrative management, technical supervision, and the monitoring of plans, combined with the autonomy of the local authorities regarding reconnaissance, choice of technologies, and the development of the project, applying their valuable knowledge.

4. The Office in Support of the Commissioner 558 of the Autonomous Region of Friuli Venezia Giulia: The Organization of a Post-Emergency Action Plan

The Autonomous Region of Friuli Venezia Giulia built a management model for achieving the set objectives within the strict and imperative deadlines, defining both a logistical and administrative system.

At the heart of the logistical apparatus was the Commissioner's Support Office 558, headed by the Delegated Commissioner, a structure set up in the days immediately following the disaster, which initially counted only six people and complemented the field work of the Regional Civil Protection Department. The office staff were strengthened over time to adequately cope with the great workload expected, reaching 25 officials and collaborators involved in coordinating the post-emergency phase. The mission that the Office was entrusted with was to supervise all aspects of the implementation process of the interventions, and to coordinate the work of all the territorial management entities that contributed to the definition of hydrogeological risk reduction mechanisms and planning tools for the use of land, including: municipalities, regional departments, chambers of commerce, consortia, in-house companies of the region and, in general, all subjects managing strategic structures and infrastructure. The involvement of these stakeholders was based on the need to join forces, and founded a catalyst in the burning desire of all parties to contribute to the reconstruction of the lands devastated by the natural disaster. By distributing the implementation of the measures, it was possible to proceed quickly to repair the huge damage in a coordinated and effective manner, using the available funds to carry out as many works as possible to quickly secure the critical areas while ensuring a high level of technical execution (Figure 7).

At the heart of the administrative apparatus of the Vaia Model was a structural organization based on the distinction of the actors involved in "Implementing Parties" and "Auxiliary Parties". The former denomination gathered public asset managers who did not have budgetary constraints, and thus had greater accounting flexibility and internal tools to manage large projects independently, relying on the Support Office almost exclusively for access to funds and the reimbursement of expenses incurred. The latter grouped together local authorities such as municipalities, inter-municipal territorial unions and mountain communities that had budgetary constraints. They were given the task of surveying, planning, and carrying out interventions, while keeping both the approval of projects and the payment of expenses centralized. The "Auxiliary Parties" were all answerable to a single "Implementing Subject": the Commissioner's Delegate 558, Vice-President and Deputy Minister for the Civil Protection of the Autonomous Region of Friuli Venezia Giulia, who acted through the Support Office and the Civil Protection Department. The key to

the success of the system was in relieving local authorities, especially small municipalities, from dealing with complex accounting systems, by giving them direct access to resources and allowing them to concentrate on the design and implementation phases of the works, knowing that they could count on a solid supporting structure.

Figure 7. Aerial view of one of the areas hit by Vaia in Friuli Venezia Giulia [2].

For both subjects, the Support Office defined the procedures for carrying out the interventions and the relations between the parties involved, provided a uniform interpretation of the exceptions to the regulations that the state of emergency made possible to apply, and offered a space for exchanges and meetings, both physically and through a network, allowing all the subjects involved to cooperate in achieving the shared objective. Programming is defined each year by the office, which monitors compliance with the dictated guidelines, the timetable, the fiscal procedures, and the quality of the whole process in accordance with the law and following the collection of the necessary authorizations.

One of the main difficulties at the start was coordinating such a heterogeneous variety of contributions: it was decided to create an online archiving platform that would be a real shared working tool, called the "Commissioner's Portal". Its structure was designed in 2018 and improved over the years based on the feedback received year by year, becoming increasingly complete and user-friendly, until it became not only a cloud but a platform for exchange and interaction that guaranteed authorized parties access to all project documents, authorization acts, and accounting documents. However, the use of an online management system was not customary for all users: the actors involved came from very different backgrounds and not all were equally familiar with the digitization of procedures. The Support Office was, therefore, also committed to enhancing digital literacy, offering help in using these tools, in person and remotely, aware that this growth would be useful not only for the achievement of the objectives of the three-year post-emergency Vaia programming period but for the efficiency of the same small local administrations that would benefit from it in all their territorial government activities.

Through the sharing of information, coordinated by the Support Office and filed in the Commissioner's Portal, and organized with actors and constant monitoring, it was possible to allocate funds and complete the planned projects, especially in the most marginal and complex areas. By coordinating the actions of the stakeholders involved in securing the territory from the damage caused by Vaia and increasing its resilience, the Support Office ensured the application of the correct risk prevention measures by offering a model applicable throughout the region. The multi-annual program defined by the Commissioner looks

at a broader framework of transformation, where each individual intervention contributes to strengthening the territorial response to natural disasters.

5. Conclusions

Launched to manage exceptional scenarios and backed by the quality of its tangible results, this proven system has become a model of governance for all fragile areas in the region. The aim of the Commissioner's Support Office 558 was to bridge the gap between national planning and local administration, encouraging the adoption of cutting-edge governance measures even in the most remote territories. This system has become a management model for promoting innovation and spreading the integration of climate change adaptation measures: the centralized management of the system ensures speed of action and supports local expertise by enabling them to carry out significant engineering work. The effectiveness of this strategy lies in understanding what the strengths of each party are and what burdens can be lifted from the actors involved in order to streamline the whole procedure and achieve as many objectives as possible in the shortest possible time, while preserving the quality of the work. The synergy between the region and the local authorities is reinforced, and the mutual support agreement confirms the solidity of an even more successful partnership.

The spread of digitalization continues: the Civil Protection Department of the Autonomous Region of Friuli Venezia Giulia has embraced the new networking tools put in place in the post-emergency phase and is integrating them into its emergency response system, so as to ensure continuity in communication and monitoring at every stage. At the same time, the Regional Civil Protection Department continues to invest resources in the development of digital prevention and warning tools for exceptional atmospheric events, which produce both outputs dedicated to specialized technicians and outputs available to citizens, presented through a simple and intuitive interface. Easily accessible from the website, and from a dedicated app soon to be developed, a dynamic map, updated in real time, shows the forecasts processed by the regional radar for the following hours, precisely delimiting the areas exposed to greater danger, subject to exceptional natural phenomena such as the Vaia Storm. This tool is designed to spread the alarm quickly, alerting each user immediately, and to offer a very precise and early picture of what the most at-risk area will be in order to find shelter [10].

The Vaia case study shows the importance of a holistic and synergistic approach, demonstrating that the use of innovative technologies is not limited to privileged territories at the center of large service networks; on the contrary, this management model can be applied to spread the adoption of climate change adaptation measures. The formative value of this system includes a commitment to the dissemination of digitalization and the integration of new planning standards for hydro-geological risk mitigation. Their inclusion in spatial planning instruments at the local scale ensures significant increases in the resilience of critical areas in responding to severe weather events.

The Commissioner's Support Office 558 plays a central role in the control of a capillary system capable of providing the overall image designed for a profound transformation oriented towards securing the territory, and is a replicable model. Cases such as this must be catalysts for significant change in land use and development planning, introducing new objectives that aim at moving towards a system of governance that is increasingly sensitive to climate change.

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Using the SDGs to Reset Travel and Tourism after COVID-19: Adopting a Culture of Health †

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Abstract: The COVID-19 pandemic represents a health crisis with profound economic impacts that served to amplify disruption in the travel and tourism (T&T) sector. Sustainability, health, and business are intimately entwined in T&T such that pandemic risk mitigation measures, from social distancing and closure of airports, resorts, and hotels, materially damaged the sector. While reduced T&T activity may have alleviated some of the negative impacts of T&T on people and the planet, it presented an opportunity for businesses and destinations to consider how they would come back. The sector can 'build back better' by pursuing sustainability. More sustainable T&T could help fragile ecosystems to recover and enable the fullest contribution of the sector to the Sustainable Development Goals (SDGs). Many leaders of T&T business are now looking beyond improving operational sustainability to think more about strategic matters and the systems in which they operate. This latest pandemic could prove to be an important accelerator in T&T's pursuit of sustainability and the SDGs. The 'Culture of Health' framework could help the sector advance sustainable T&T, drawing out the trade-offs and dilemmas presented by its activities.

Keywords: travel and tourism; COVID-19; culture of hHealth; sustainable development goals; sustainable tourism; tourism

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1. Introduction

Travel and Tourism (T&T) is a "social, cultural and economic phenomenon which entails the movement of people to countries or places outside their usual environment for personal or business/professional purposes" [1]. Before the COVID-19 pandemic, T&T represented a major global business sector that was growing fast year-on-year [2]. The pandemic affected the traveler experience across the T&T value chain, whether this was simple closure of facilities or restrictions on travel per se. Even now, some barriers to travel remain, whether actual or perceived, with destination requirements on testing and vaccine mandates affecting the free movement of people.

The T&T sector is a "key driver for socio-economic progress" [3] given its significant contribution to the economy of many countries. It contributed 10.3% to global gross domestic product (GDP) in 2019 [4]. At that time, it earned over USD 8.9 trillion, representing 10% of jobs worldwide (330 million) and 20% of new jobs over the last five years, with a 3.5% growth outpacing that of the global economy at 2.5% in 2019 [4]. Domestic tourism was 71.3% of total tourism spending in 2019, with the sector employing a high proportion of women [4]. With 1.5 billion international tourist arrivals in 2019, international travel was predicted to grow by some 35% [5], giving 1.8 billion international arrivals by 2030 and domestic tourism up to four times this amount [6,7].

The T&T sector experienced six decades of growth [8], outperforming growth projections by the United Nations during the period 2010–2019, with emerging economies accounting for almost a half of international travel arrivals in 2017 [9]. Late 2019 forecasts

predicted tourism arrivals to increase by 3–4% globally in 2020 [10]. International tourism is, however, just a small part of the overall picture, with domestic tourism key in most large nations, e.g., in the U.S., international arrivals account for only 3.3% of person-trips [11]. The growth of T&T looked set to continue unabated, fueled by budget airlines lowering the costs of travel and technology platforms for accommodation and travel searches.

However, with these growing numbers came mounting concerns about the detrimental impact of T&T on people and the planet. Some countries and destinations were overly dependent on financial receipts from T&T, and many destinations suffered from poorly designed tourism infrastructure leading to tensions with local communities. Given T&T's links to other economic sectors, from agriculture to transport, the sector impacts widely on natural and societal resources from water scarcity to community cohesion.

New terms, including 'flygskam', or 'flight shaming' [12], and 'overtourism' [13], have been coined to draw attention to the negative issues relating to T&T. Given that the international arrivals of just twenty countries together exceed that of the rest of the world [14], these are especially acute. Severe impacts of overtourism led to the closure of Boracay Island in the Philippines to tourists to minimize harm [15] and were the subject of protests by local citizens in Amsterdam and Venice [16]. While destinations and T&T businesses have developed traveler dispersion policies and strategies to shift traveler behavior, such as targeting higher-value overnight travelers rather than day-trippers [14], a more concerted approach is needed.

The worsening environmental footprint and detrimental community impacts of the T&T sector have spurred stakeholders to call for action [17]. For example, the United Nations Environment Program 2050 calls for T&T to adopt more sustainable practices, given concerning predictions of rises by 2050 of energy use (up 154%) and water consumption (up 152%), greenhouse gases (up 131%), and solid waste (up 251%) [18]. Efforts made by private T&T businesses and governments to tackle these challenges and pursue sustainability are important but more concerted action is needed. Some businesses are integrating into their operations more sustainable practices, while others are more focused on corporate social responsibility metrics. Few companies or organizations, however, have mainstreamed sustainability into their business strategy or the traveler's experience. At the government level, just 11% of national T&T objectives relate to sustainability [19].

Looking ahead, the actions of governments, companies and individuals will influence the nature and speed of the recovery of the T&T sector from the impact of the COVID-19 pandemic. The Organisation for Economic Co-operation and Development (OECD) report on pandemic recovery [20] warned against a return to 'business as usual' and recommends that whatever its shape or duration, sustainability is held to be a mechanism to 'build back better'. As the recent pandemic revealed fragilities in our economic and societal models, it also served to remind us that we are social animals desirous of novel experiences in support of physical and mental health. As such, there is an untapped resolve to travel again and connect with people. In this context, adopting the 'Culture of Health' framework [21] that places well-being as a strategic business priority could help accelerate the sustainability journey in T&T and the recovery of the sector.

2. Culture of Health Framework

The Culture of Health framework can be useful to help guide a reset in T&T after COVID-19, with Quelch's argument [21] being that "Every company, knowingly or unknowingly, impacts public health ... ". The framework connects health and business directly across fours domains that are highly relevant to the impact of the T&T sector:

- Consumers: through the products and services a business delivers to consumers.
- Employees: including supply chain: how a business treats its employees and supply chain workers.
- Community: how much a business invests in the health of the communities in which it operates.
- Environment: the impacts of a business on the environment.

In 2008, the United Nations (UN) Foundation, UN World Tourism Organization, UN Environment Programme, and the Rainforest Alliance developed the Global Sustainable Tourism Criteria (GSTC) [22]. These establish the "minimum requirements that any tourism business or public destination management authorities should aspire to reach to protect and sustain the world's natural and cultural resources while ensuring tourism meets its potential as a tool for poverty alleviation" [22]. There is, however, no universally accepted sustainability standard or certification for T&T, perhaps reflecting the complexity of the sector. Conscious consumerism as a trend is encouraging the sector to act, e.g., on single-use plastics [23]. However, only a few companies and destinations embrace sustainability holistically and the sector to date lacks a widescale commitment to sustainable T&T [24].

Using the Culture of Health [21] framework could help the T&T sector's pursuit of sustainability, especially at this moment after COVID-19. Health, while not called out explicitly in Environmental, Social and Governance (ESG) models, is a key factor in most. The framework's inclusion of the consumer and community as important pillars [21] alongside employees and the environment could help businesses better appreciate healthy people, a healthy planet, and healthy prosperity. In this way, T&T can explore the wider scope of sustainable practices. In a world after the COVID-19 pandemic and living with the virus, businesses that adopt a Culture of Health could emerge more environmentally and socially sustainable, as well as more economically viable [25]. The model sits comfortably with the Sustainable Development Goals (SDGs) [26] that can be positioned as a shared purpose around which to build a culture of health. This offers a way for the sector to both foster sustainability and reset after the pandemic. In this way, T&T, as a force for good, can help recover global economies and livelihoods while accelerating its efforts to attenuate and repair its negative impacts on the environment.

2.1. Consumers: Through Products and Services a Business Delivers to Consumers

The pandemic is unlikely to affect the desire for travel, with tourism connecting people and places. As tourists make decisions about where to travel, when, why and how, their considerations will likely focus more on health alongside other considerations such as affordability. This will include health across all its domains, from understanding safeguards should they fall ill while traveling to assurances that the staff and destination take health seriously. Travelers will embrace more conscious consumerism, with a focus on responsible T&T businesses. New opportunities are anticipated in health and wellness, as tourists prioritize trips that offer peace and tranquility and seek immersive experiences in nature and focus more on domestic travel.

2.2. Employees: How a Business Treats Its Employees and Supply Chain Workers

The pandemic brought to the fore employee health and well-being and the case for protecting frontline workers, as well as those in the supply chains. Lockdowns and trading restrictions have had a disproportional effect on small- and medium-sized enterprises (SMEs) that support tourism [27]. Investment in supply chain resilience could help promote local sourcing with consequent reductions in environmental impact. The pandemic also revealed inequities related to the social determinants of health that showed up among workers.

2.3. Community: How a Business Invests in the Health of the Communities in Which It Operates

Within the community pillar, the T&T sector needs to pay more attention to the needs of residents and the preservation of local traditions and culture. Destinations can focus more on enhanced visitor flow management, use of technology and infrastructure investments. Given restrictions and barriers to international travel, a focus on driving up demand among domestic and regional travelers has encouraged citizens to explore their own countries and their different communities. This increased interest in localism, as well as the opportunity for many to work remotely, could see a rise in 'slow' tourism [28] with travelers spending more time in a destination and experiencing more authentic local events.

2.4. Environment: The Impacts of a Business on the Environment

Within the environment pillar, products and services offered by T&T providers as well as their pricing should reflect their total impact. The deleterious impact of the sector, including its input to carbon emissions, freshwater use, and waste needs to be balanced alongside its positive and restorative contributions to conservation efforts and equity, with further consideration of its impact on cultural and heritage artifacts and ways of living [29]. Research that develops a 'true' cost for T&T, using, for instance, the impact weighted accounting principles [30] or total impact measurements [31], would be tremendously valuable for the sector, as it would extend ESG reporting to include the health of the natural world as a key metric. There is a significant opportunity to further develop multinational and global coordination to advance sustainability policies and frameworks in T&T.

By focusing on sustainability as health across all four pillars of the Culture of Health framework (see Figure 1), T&T can focus its reset on sustainability and make its fullest contribution to the SDGs in helping global economies and livelihoods recover [20].

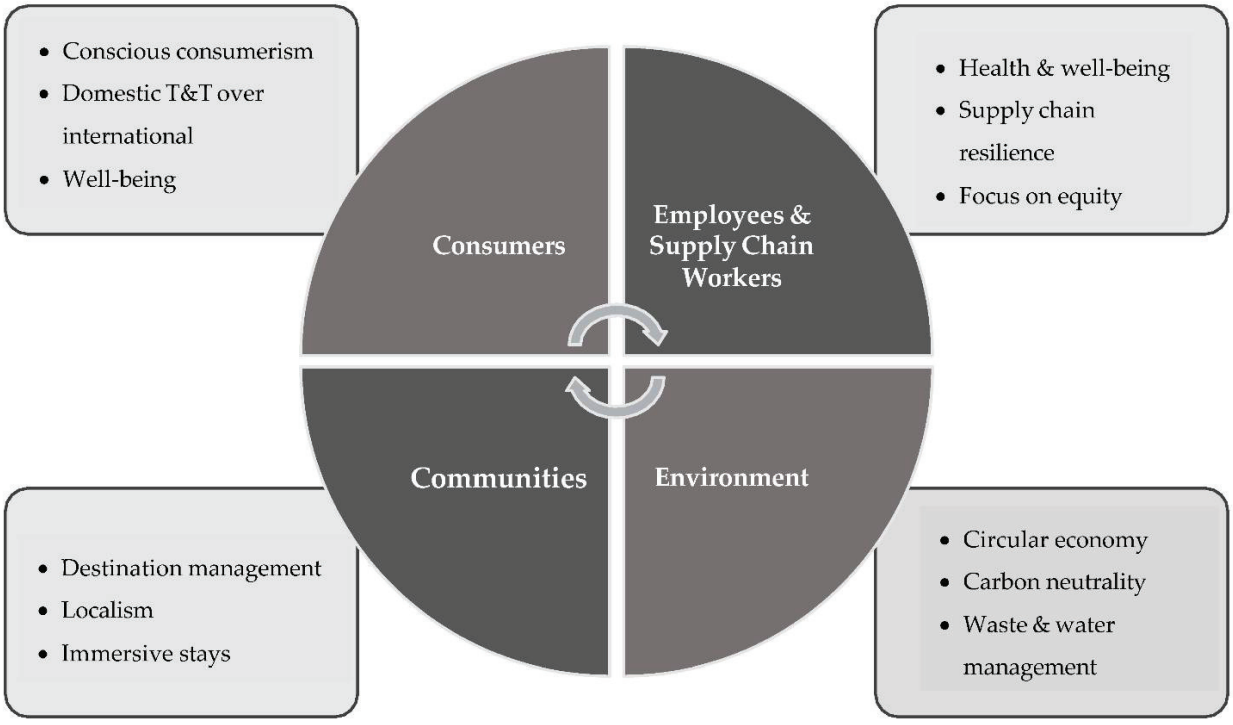

Figure 1. The Culture of Health Framework to Advance Sustainable T&T: Examples of Trends within each Domain.

3. Conclusions

Considering the devastating impact of COVID-19 on T&T [32], there is a unique opportunity to reset T&T by embracing sustainability through the SDGs with deliberate re-opening strategies that seek to advance the many positive contributions of the sector and attenuate its deleterious impacts. Careful stewardship of T&T central assets of nature and culture requires all stakeholders to work together accompanied by appropriate regulatory oversight and responsible personal choice. We are already seeing demand for T&T begin to recover [33]. Whatever the sector does to rebuild after the pandemic, people's health (customers, employees, and workers in the supply chain, and those in the community) and the environment are central to sustainable T&T. The sector must consider explicitly its impact on people, planet, and prosperity, in advancing economic interests and the quality of life in destinations. Applying health as a strategic lens for business is a way to connect these agendas.

The COVID-19 pandemic illustrated the interconnections among human health, planetary health, and economic health. The foundation of sustainable T&T is paying attention to the human health impacts of human-caused disruptions to the Earth's natural systems. The SDGs can be adopted as a shared purpose for T&T to fuel a reset of the sector in its pursuit of sustainability. In this way, T&T can be a force for good in helping safeguard fragile communities and ecosystems and create a more sustainable economy. While lockdowns and reduced T&T business during the pandemic may have enabled us to savor cleaner air or traffic-free roads, stopping travel for business and pleasure is not the answer to progressing a more sustainable sector. Rather, T&T needs to be core to a sustainable global economy [34]. The pandemic showed us that gathering humanity around a problem to work collectively with a global mindset works; this is a blueprint for tackling climate change. The next normal for T&T can be defined by the pursuit of sustainability. Travelers are already more intentional about the experiences they seek and the impact they have on our world, with growth in experiential, immersive, and community-based travel for education and learning [35,36]. T&T enterprises can now better integrate triple-bottom line accounting and sustainability management systems to ensure companies track and report results transparently.

The Culture of Health framework [21] could help the T&T sector 'build back better' after the COVID-19 pandemic. As T&T businesses join forces to accelerate the sector's sustainable recovery, actions they might consider:

- Including health as a specific domain within their ESG reporting and Sustainability Strategy, selecting appropriate metrics.
- Accounting for the public health benefits of switching to renewable energy sources and/or transitioning to electric vehicles using available impact models.
- Re-framing corporate social responsibility projects as a strategic corporate social innovation agenda, capturing investments in community endeavors.
- Connecting investments in workforce development, education, and training to advancing a culture of well-being.
- Promoting healthy behaviors among all stakeholder groups.
- Ensuring equity is understood as a key outcome of a healthy business culture and operations.

The T&T sector can create and sustain shared value by protecting people and the planet over the long-term, delivering against a global mission to create a world where "no-one will be left behind" [26]. This is the time for the T&T sector to forge a new social contract, with the Culture of Health framework a driver of radical transformation to reset the sector after COVID-19 by embracing the SDGs.

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Proceeding Paper

Access to Education for Persons with Disabilities in Ghana: A Review †

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Abstract: This paper examines the inclusion of Persons with Disabilities (PWDs) in formal education through the lens of existing literature. In Ghana, special education for disabled children began in 1936, and a school for the blind opened in 1946 in Akropong-Akwapim. The review revealed that interventions targeting inclusive education in Ghana are disjointed and sporadic. It was also discovered that the developmental plans of successive administrations have ignored the needs of vulnerable children, particularly children with impairments. As a result, the report suggests that educational stakeholders consider including the needs of disabled children into standard educational planning and provisioning.

Keywords: inclusive education; persons with disabilities; sustainable development

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1. Introduction

According to estimates, children with disabilities account for around one-seventh of all children who are out of school [1] (p. 7). Disabled children are unable to obtain an education due to a variety of issues such as coming from a very poor family, being female, or having a specific condition [2,3] (pp. 69–79), (p. 3). Statistics in Ghana show that almost 623,500 children of primary school age are still not registered and one out of every four children in the kindergarten age group (four to five years old) is not enrolled in pre-school [4]. According to the 2010 population and housing census, 20% of children with physical disabilities do not attend school [4]. In addition, four out of ten PWDs aged three and above have received no formal education, while 17.4% have completed basic school [4].

When children with disabilities are denied access to education, it marks the start of their social isolation and marginalization. Children with impairments are denied suitable career opportunities later in life due to their lower level of skills.

They are also unable to participate in society and make a meaningful contribution, making it much more difficult for them to contribute to developmental interventions and efforts.

In recent years, the focus has moved to removing educational hurdles for all students by promoting Inclusive Education [3] (p. 4). This has brought attention to the role of education in fostering social justice for all individuals, particularly the disabled [5] (pp. 1–15). Although there are many meanings of Inclusive Education, all agree that it entails reorganizing regular schools and/or classrooms to meet the demands of a diverse array of youth in societies [6] (pp. 152–164). Inclusive Education is described by the Ghana Education Act (Act 778, 2008) as a value system that guides educational institutions in such

a way that all patrons have equal opportunities. The only way to bring people with disabilities out of poverty, vulnerability, and exclusion is to provide them with a high-quality, all-encompassing, and unbiased education.

To fulfil this purpose, the international community has adopted human rights frameworks aimed at ensuring that children with disabilities receive a high-quality education in a welcoming atmosphere. The 2006 United Nations Convention on the Rights of Persons with Disabilities (CRPD) intends to develop Inclusive Education as a critical mechanism for ensuring that children with disabilities have access to school [7,8] (pp. 205–227), (pp. 16–18).

People with Disabilities have the right to education under Article 24 of the CRPD. This can be accomplished by ensuring that all People with Disabilities have equal access to an "inclusive education system at all levels," as well as reasonable accommodations and individual support services to help them complete their education [9] (pp. 1–59).

2. History of Inclusive Education

The Salamanca Framework (1994), which encouraged governments to accommodate all children, regardless of their circumstances or disabilities, by ending the segregation of differently abled children, marked a watershed moment in the debate over Inclusive Education (p. 4). The concept emphasized that a child's learning ability might be affected by a variety of factors such as ethnicity, poor language articulation, and poverty; consequently, Inclusive Education is essential to ensure that all children are accommodated in the education system. [10] (pp. 746–761).

The Salamanca framework expanded the conversation about education to investigate how the system was built up as well as the barriers that stopped children from receiving an education [3]. (p. 5). Inclusive Education led to two key elements as a result of the Salamanca framework: a transition away from the assumption that children's educational needs are determined by medically diagnosed diseases or disabilities, and how to reform conventional educational systems to create a barrier-free learning environment [10] (pp. 746–761). It also supported the idea that disabilities do not always imply specific learning needs, and that children with disabilities face the same range of learning challenges as children without them.

Furthermore, children with similar disabilities do not always have the same educational needs, calling into question the classification of all disabled children as having special educational needs and the unnecessary division of them into specialised schools [3] (p. 5).

Another development aim known as Education For All (EFA) evolved as a set of moves aiming to transform special education into what is now known as Inclusive Education.

The World Summit on Education for All gave birth to the Millennium Development Goal of universal education by 2015 [11] (p. 7).

As a result, SDG 4 on education aims to provide all people with access to high-quality education while also encouraging lifelong learning [12] (p. 6). Despite the fact that UNESCO championed these two educational goals, further research shows that many EFA projects have failed to satisfy the needs of vulnerable children, notably those with impairments [5] (pp. 1–15). Despite their apparent similarity, the EFA and Inclusive Education agendas have continued to operate in tandem (p. 5). As a result of this predicament, many emerging countries have experienced substantial educational setbacks.

3. Evolution of Inclusive Education in Ghana

Dr. Kwame Nkrumah served as the Leader of Government Business throughout the final colonial period, and in 1951, he took over the State's administration. The Nkrumah government developed the "Education for All" policy in 1952, affirming the importance of education as a major tool for national growth. Dr. Nkrumah's first step was to implement the Accelerated Development Plan (ADP, 1951), which was instrumental in extending and improving Ghana's basic education. The goal of this initiative was to eliminate tuition fees and provide all children with a free basic education. During this time, approximately half a million children were enrolled in primary school. In 1957, the number of primary schools

rose from 3571 to 3713, while the number of middle schools rose from 1311 to 1394 in 1959 [13] (pp. 29–40). The Educational Act of 1961 created an indirect provision for children with special needs by making education free and obligatory for all children of school age. The Ghana Education Service's Special Education Division, for example, was founded in 1962 to meet and support the educational needs of Ghana's Persons with Disabilities. It is worth mentioning that the British had a major impact on the early provision of special education in Ghana [13] (pp. 29–40).

Ghana's special education conditions have gradually improved. The number of students with impairments enrolled in specialist schools increased by 40.5% (3361 to 4722) between 2001/2002 and 2005/2006 [14] (pp. 28–32). The Education of Children with Disabilities Act is linked to the 1961 Education Act, and the provision of Free Compulsory Universal Basic Education (FCUBE) is ensured in Ghana's 1992 constitution.

FCUBE is a policy aimed at ensuring equal access to education for all children. These programmes did away with the use of levies to collect funds for running expenses and instead provided meals to children in need.

During the pilot process in the academic year 2004/2005, the capitation grants programme offered ₵3.5 per female pupil and ₵2.5 per male pupil [13] (pp. 29–40). In addition, the government has taken steps to establish committees to examine vocational training policies for PWDs. The foundation of Inclusive Education (IE) in Ghana is primarily based on international and national educational legal frameworks. Inclusive Education is defined as an approach in which schools are structured to accommodate children with disabilities and other disadvantaged children in order to improve their right to equal education, inclusion, and participation in other societal affairs, according to the Education Strategy Plan (ESP) 2010–2020 [13] (pp. 29–40). While initiatives to implement Inclusive Education on a pilot basis have been made, there remain obstacles inhibiting its advancement in Ghana. "While trends are shifting toward more inclusive approaches, institutionalization of people with learning disabilities and other disabilities continues to be a common practice," writes Avoke [13] (pp. 29–40). Due to the enactment of Disability Act 715, people with special education needs will now be able to attend regular schools.

4. Methodological Approach

This article examines the scientific literature on all-inclusive education as a social welfare service for disabled children, taking into account existing hindrances to access. The review delves into the study's main topics, including stigmatization and prejudice, cultural values, policy and institutional failures. The article explores peer-reviewed papers and assessment reports found through internet searches (primarily Google scholar and online academic repositories). Many review articles on Inclusive Education have focused on these scientific literature sources. Both Wapling's review of Inclusive Education and children with disabilities in relation to the quality education for all in Low- and Middle-income countries [3] and Mantey's review of accessibility to Inclusive Education for children with disabilities in Ghana [15] used web-based searches to gather relevant information.

The literature was searched for information on the state of disabled people's access to school, the progress of Inclusive Education in Ghana, and the history of Inclusive Education in Ghana.

5. Review Results

This paper is purely a review study; as such literature on various issues hindering Inclusive Education is examined with the view of understanding the various narratives underpinning the full and effective implementation of Inclusive Education. This section presents a review and discussion of the various factors hindering the effective implementation of Inclusive Education.

5.1. Infrastructural Barriers Affecting the Implementation of Inclusive Education

To guarantee that children with disabilities have access to and benefit from school, it is necessary to remove the barriers that prevent them from fully participating. In Ghana, most schools are built without taking into account the requirements of impaired children. Narrow doorways, many floors with no ramps or lifts, and inaccessible washroom facilities are just a few of the obstacles disabled children are faced with [9] (pp. 1–59). This is especially critical for physically disabled youngsters. Special schools in metropolitan areas are among the few schools that meet the standards for accessibility for people with disabilities. This means that the majority of disabled children living in rural areas are unable to attend school due to transportation concerns.

It is also important to make sure that the manner of communication is appropriate for impaired youngsters. In terms of teaching and learning materials, most schools are under-resourced, and lack Braille, big print, visual, audio, and sign-language materials. This further marginalizes children with impairments in the educational process [9] (pp. 1–59).

5.2. Socio-Cultural Barriers Affecting the Implementation of Inclusive Education

Discriminatory attitudes and misconceptions about disability also make it difficult for People with Disabilities to participate in school on an equal basis with their non-disabled peers [9] (pp. 1–59). In many Ghanaian societies, disabled individuals are refused access to education because disabled children are considered as a disgrace to their family and should not be compelled to attend school [16] (pp. 7–8). The bullying and harassment of children with disabilities is common among their peers and teachers, lowering their self-esteem and potentially leading to school dropout. The situation for women and girls with disabilities in Ghana is worsened by societal biases against women [16] (pp. 7–8). According to Shevlin, Kenny, and McNeela [17] (pp. 159–169), students with disabilities are denied admittance to science-related courses in developed countries such as Ireland and China, based on the belief that a disabled student will 'waste' the degree due to his or her inability to work.

This only makes the situation worse for disabled people. Apprenticeships or work training that is available to disabled adolescents on the job market is highly challenging [16] (pp. 7–8).

5.3. Policy and Institutional Setbacks Affecting the Implementation of Inclusive Education

Another source of worry is the policy and institutional structure that governs educational management. In Ghana, there is no specific policy guiding the operation of special education; instead, special education is covered by the general education policy [18] (pp. 22–38). Special education activities are so closely linked to general education activities that special schools follow the general education curriculum with minimal changes to accommodate the needs of distinct groups of disabled children [18] (pp. 22–38).

In addition, the Ghana Education Service maintains a Special Education Division (SPED) that is responsible for implementing special education regulations and supervising the functioning of special schools. SPED is thus one of the ministries of education that receives funding from the federal government. SPED, on the other hand, only receives a small part of the total funds allocated to the sector each fiscal year. SPED, for example, received 0.7 % of educational revenues in 2010, 0.5% in 2011, and 0.4% in 2012 [18] (pp. 22–38). This is woefully inadequate to meet the learning demands of Ghanaian children with disabilities.

5.4. The Relationship between Educational Attainment and Employment Opportunities for PWDs

The relationship between educational attainment and the likelihood of better work chances has been studied and proven [19,20] (pp. 1–13), (pp. 1–11). According to Filmer [21] (pp. 141–163), each additional year of schooling lowered the chance of a disadvantaged person and his or her household falling into the poorest two quintiles by 2–5%.

Afoakwah and Dauda [22] (pp. 1–24) reported in a study on employment status and educational attainment among disabled Ghanaians that people with visual or physical

disabilities, as well as people with hearing impairments, had a statistically significant chance of receiving job offers if they had been through higher education.

6. Conclusions and Recommendations

Inclusive Education has been welcomed and recognised on a national and international level, and it is seen as a human rights issue. For school systems all across the world, inclusion is a major issue. Although there are many interpretations and definitions of an Inclusive Education, there is a common thread that runs through all of them. According to authors including Pearson [23] (pp. 25–32) and Beveridge [24] (pp. 1–62), a permanent understanding of Inclusive Education has not been established, which makes its implementation challenging. Overall, the literature demonstrates a lack of clarity and consensus on what constitutes Inclusive Education, as well as significant disagreements about how much of it is dedicated to children with disabilities [25] (pp. 1053–1071). Aside from the vagueness of the situation, it appears that the international community lacks support for the development of inclusive or special education for disabled children. This lack of a worldwide consensus likely makes it more difficult for governments to develop Inclusive Education systems capable of appropriately serving all pupils [20] (pp. 1–11).

Due to their absence from significant global programmes such as free primary education and Education For All, governments have found it increasingly difficult to devote the required resources to support poor children.

One element that could help ameliorate this scenario is encouraging the integration of the needs of children with disabilities into traditional educational planning and provisioning. It is desirable to include impaired children in traditional education programs, initiatives, funding, and donor support. In terms of planning, resource allocation, and supervision, the education of disabled children should not be separated from that of non-disabled children.

Small changes to the physical environment, such as classrooms, dining areas, play and sports areas, and WASH facilities, can make a big difference in how comfortable certain handicapped students feel in mainstream schools. This is one area where short-term resources should be directed towards to ensure that children can be physically accommodated and that teachers, classmates, and parents are properly educated. Because of unacceptable behaviors or inaccessible infrastructure, it is vital to ensure that pupils are not unfairly rejected or placed in special schools.

In order to make education accessible to Persons with Disabilities in Ghana, there is a long-term need for institutional reform and restructuring. The Ministry of Education, in collaboration with other governmental and non-governmental groups, must develop a strategic plan to ensure that impaired children are enrolled in mainstream schools alongside their non-disabled counterparts.

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Proceeding Paper

Localizing the 2030 Agenda at the Regional Level through the European Cohesion Policy: An Application to the Region of Sardinia †

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Abstract: The 2030 Agenda represents a natural framework to guide the post-COVID recovery process. However, the assessment of the effectiveness of sustainable development-oriented policies is still a challenge, and addressing this problem is now more urgent than ever. Fondazione Eni Enrico Mattei and the Autonomous Region of Sardinia launched a research project aimed at developing a model to assess the extent to which the operational programs co-financed by the EU under the Cohesion Policy are sustainable in terms of SDGs. The method developed allows policymakers to direct spending toward investments to better pursue the 2030 Agenda targets. The paper presents the key features of the model and its results applied in the Sardinian context.

Keywords: sustainable development; 2030 Agenda; SDGs; European Cohesion Policy; localization

1. Introduction

In September 2015, with the adoption of the 2030 Agenda and its 17 Sustainable Development Goals (SDGs), 193 UN Member States decided to make an important commitment: to leave no one behind.

With regard to the 2030 Agenda and its localization, of considerable interest is the role of European institutions and, in general, the stakeholders involved in the definition of the EU Cohesion Policy 2021–2027. In fact, the institutions involved in the definition of the Cohesion Policy have highlighted the importance of the UN 2030 Agenda SDGs and their strategic significance for the future of the European Union. Since the 2016 European Commission Communication on the 22nd of November [1], the European Union, with its Member States, has been fully committed to the implementation of the 2030 Agenda and its SDGs, as reiterated in the conclusions of the Council of the European Union "*A sustainable European future: The EU response to the 2030 Agenda for Sustainable Development*" [2] and the European Commission's reflection paper "*Towards a Sustainable Europe by 2030*" [3]. The latter clearly affirms the role of the Union in the definition of the 2030 Agenda and

sets the goal of fully integrating the SDGs into the EU strategic framework and policies. Right after, the von der Leyen Commission decided to integrate all the SDGs into its six Political Guidelines.

As noted by the European Court of Auditors [4], despite the EU's commitment to sustainability and the Sustainable Development Goals, the European Commission fails to report on or monitor how the EU budget and policies contribute to sustainable development and the achievement of the SDGs. As a result, the Commission is currently looking into the adoption of a mechanism to track the EU budget in terms of SDG spending [5].

In fact, it is crucial to develop tools that can provide an overview of how investments contribute to the Union's strategies, including the 2030 Agenda. The assessment of the effectiveness of sustainable development-oriented policies has always been a challenge, and addressing this problem is now more essential than ever, especially in the current emergency.

In this context, the present study aims to implement a sustainability assessment model to study the extent to which the operational programs co-financed by the EU are sustainable in terms of the UN 2030 Agenda SDGs, taking into consideration the significance that the SDGs have for the EU and the central role of Cohesion Policy for the SDGs' achievement.

The paper is divided into two parts: the first section describes the assumptions and the theoretical framework of the model developed and its update; the second section reports the results of different applications of the model, referring to the Sardinia European Regional Development Fund (ERDF) and European Social Fund (ESF) 2014–2020 Regional Operational Programmes (ROPs). The conclusions follow.

Despite being designed and built specifically for the 2021–2027 programming period, the model can be applied to current ROPs (as well as national OPs) to validate previous findings and detect any reorientation effect of spending following the COVID-19 pandemic.

2. Materials and Methods: The Assessment of the Contribution of the Cohesion Policy to the SDGs

Before going into the details of the model, the next sub-section outlines the main aspects of the Cohesion Policy for the 2021–2027 programming period, as described in the recently approved EU Regulations [6–10].

2.1. The European Cohesion Policy 2021–2027

The Cohesion Policy intends to improve the European Union's economic, social, and territorial cohesion as well as remedy the inequalities between countries, regions, and cities.

This policy is one of the most horizontal and cross-cutting policies of the EU, contributing to the majority, if not all, of the 17 Sustainable Development Goals. Furthermore, fundamental cross-cutting principles and objectives, such as sustainable development, eliminating inequities, promoting gender equality, integrating gender perspectives, and combating discrimination, are mainstreamed at all levels of policy implementation [3].

The EU Cohesion Policy is financed through the EU's long-term budget, the Multi-annual Financial Framework (MFF), with resources amounting to EUR 373 billion for the programming cycle of 2021–2027 [11].

The European Structural and Investment Funds are specifically used to execute the Cohesion Policy by distributing the resources provided under the MFF. In particular, the structure of MFF for the 2021–2027 programming period was revised and simplified as described by the Regulation (EU) 2021/1060 (Common Provisions Regulation, CPR) [10], which establishes common rules applicable to the following funds: the Cohesion Fund (CF), the European Regional Development Fund (ERDF), the European Social Fund Plus (ESF+), the European Maritime and Fisheries Fund (EMFF), the Asylum and Migration Fund (AMIF), the Border Management and Visa Instrument (BMVI), the Internal Security Fund (ISF), and the Just Transition Fund (JTF).

The methodology presented here was developed considering only the European Regional Development Fund (ERDF) and the European Social Fund Plus (ESF+).

In general, the 2021–2027 Cohesion Policy focuses on five policy objectives [10]:

1. a more competitive and smarter Europe by promoting innovative and smart economic transformation and regional ICT connectivity;
2. a greener, low-carbon transition toward a net-zero carbon economy and resilient Europe by promoting clean and fair energy transition, green and blue investment, the circular economy, climate change mitigation and adaptation, risk prevention and management, and sustainable urban mobility;
3. a more connected Europe by enhancing mobility;
4. a more social and inclusive Europe implementing the European Pillar of Social Rights;
5. a Europe closer to citizens by fostering the sustainable and integrated development of all types of territories and local initiatives.

The majority of the ERDF investments are focused on the first two goals; ESF+ investments, on the other hand, are entirely focused on the fourth goal.

The five aforementioned objectives are then divided, for the ERDF and the ESF+, into further specific objectives: 23 and 13, respectively. The latter is pursued through investments traced into intervention fields. Each Member State and region chooses the intervention fields that best serve its objectives on the basis of its strategic choices, taking into account country-specific recommendations, challenges identified in the Integrated National Plans for Energy and Climate, principles of the European Pillar of Social Rights, and, where appropriate, the National Recovery and Resilience Plans.

Furthermore, the operations/interventions financed by both the ERDF and the ESF+ must be in line with the European objective of promoting sustainable development, taking into account the SDGs of the UN 2030 Agenda, the Paris Agreement, and the "*do no significant harm*" principle.

2.2. The Methodology

As previously stated, the Commission is now looking into adopting a system for monitoring the EU budget in terms of the Sustainable Development Goals [4,5].

In particular, the European Commission has already established a framework to calculate the contribution of European Structural and Investment Funds to climate change goals [12]. This method, based on the Rio Markers system [13], consists of assigning a weight to each intervention field, determining whether and how the ESI Funds affect climate change mitigation and adaptation goals.

In this context, a recent study [14] commissioned by the European Parliament's Committee on Budgets showed how the Commission's methodology often leads to an overly "generous" estimate of the climate-relevant expenditure in several of the intervention fields.

In this regard, RAS and FEEM have launched a joint research project specifically aimed at developing and implementing a model for assessing the sustainability of the Regional Operational Programmes (ROPs) [15,16]. The project took inspiration from the model developed by RAS in the Strategic Environmental Assessment (SEA) procedure of the 2014–2020 ROPs [17], in line with the methodology introduced by the European Commission [12].

The methodology is intended to be a valuable tool to assist decision-makers in identifying the most effective programming options with regard to the 2030 Agenda SDGs.

The authors investigated the interconnections between the 169 targets of the 2030 Agenda and the CPR funds' 182 intervention fields [10] (in the above-cited previous publications [15,16], only 143 intervention fields were considered in the analysis) through the creation of three matrices: the first one captures the type of impact, classified as null, indirect, or direct; the second one describes the orientation and the magnitude of the impact (negative or positive; null, very low, low, medium, and high); and the last one is the product of the aforementioned matrices.

In general, the development of the model has implied the steps represented in Figure 1; for further details on the methodology see [15,16].

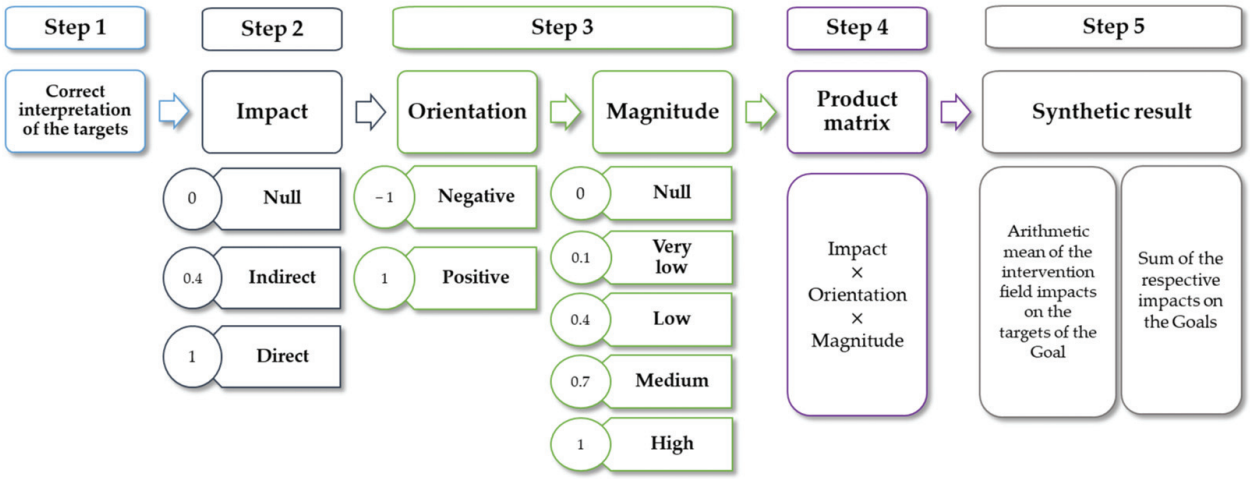

Figure 1. The model-building process. Sign "×" stands for "multiplied by".

Analyzing the final coefficients (Figure 2) of the developed model highlights how the investments (represented by the intervention fields) supported by the Cohesion Policy cannot be a "one size fits all" solution for the achievement of every 2030 Agenda target. Rather, tackling the SDGs requires the use of a variety of financial tools as well as the implementation of non-economic measures, such as a global framework for both regulations and collaboration.

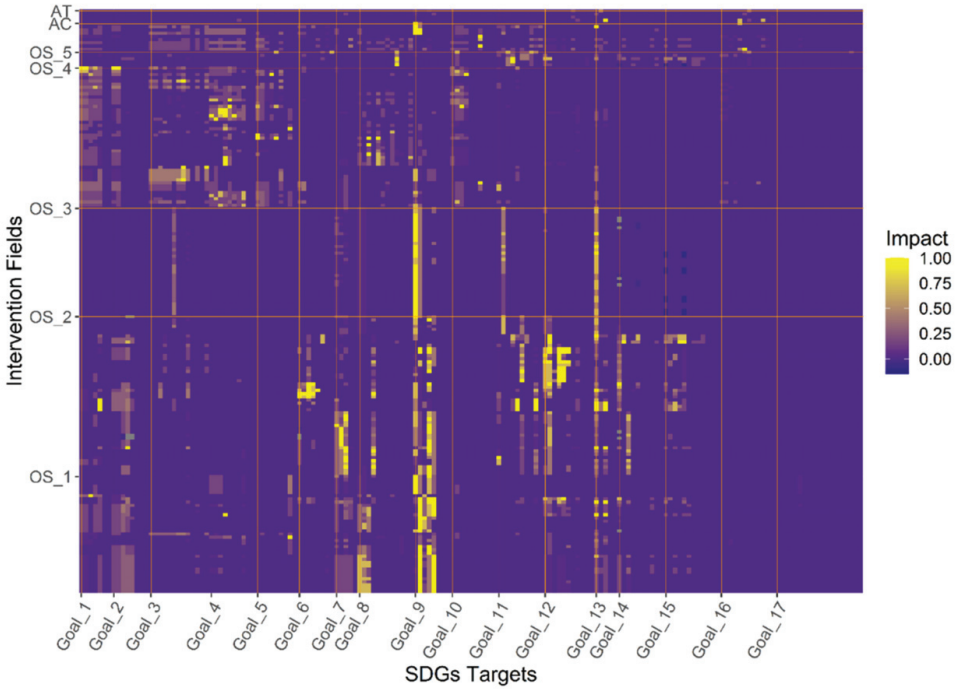

Figure 2. Heatmap for the final coefficients.

Figure 2 shows that most of the intervention fields have low or no impact on the SDGs, especially for Goal 17, "*Partnerships for the Goals*", and Goal 16, "*Peace, justice and strong institutions*". On the contrary, Goal 9, "*Industry, innovation and infrastructure*", is the most impacted one, followed by Goal 13, "*Climate action*"; Goal 7, "*Affordable and clean energy*"; and Goal 1, "*No poverty*".

A very important aspect to point out is that the EU pursues the UN 2030 Agenda's SDGs through a set of policy programs; one of these is the Cohesion Policy, whose objec-

tive, as previously mentioned, is to strengthen European regional economies and correct imbalances between them. In this respect, the "global" nature of the 2030 Agenda targets influences the findings: some of the targets refer exclusively to developing nations, whose difficulties are unlikely to be addressed through the European Cohesion Policy.

Going into detail, the following paragraphs explore the results obtained from a matrix built specifically for the Sardinia Region and composed horizontally by the targets of the 17 Goals of the 2030 Agenda and vertically by the 182 intervention fields.

What emerges from the horizontal analysis dealing with intervention fields' contribution is that the field that has the greatest impact on the SDGs is 046, which is "*Support to entities that provide services contributing to the low carbon economy and to resilience to climate change, including awareness-raising measures*". Specifically, this intervention field presents its largest contributions to the achievement of Goal 13, "*Climate action*", and Goal 7, "*Affordable and clean energy*".

In second place in terms of its contribution to the SDGs, we have intervention field 029, "*Research and innovation processes, technology transfer and cooperation between enterprises, research centres and universities, focusing on the low carbon economy, resilience and adaptation to climate change*", followed by field 023, "*Skills development for smart specialization, industrial transition, entrepreneurship and adaptability of enterprises to change*", and field 064, "*Water management and water resource conservation (including river basin management, specific climate change adaptation measures, reuse, leakage reduction)*".

By contrast, the intervention field that contributes less to the achievement of the 2030 Agenda is 180, "*Preparation, implementation, monitoring and control*", which relates to the technical assistance policy objective, targeted at improving the public administration and the program's communication approach; this is a type of transversal tool that the national/regional organization can use.

Another point worth considering is the presence of intervention fields that may have a negative impact on specific 2030 Agenda Goals. For example, investments in seaports have negative impacts on Goal 14, "*Life below water*", and investments in the construction of roads, highways, and railways have negative effects on Goal 15, "*Life on land*".

Regarding the vertical analysis of the Sustainable Development Goals, the most impacted Goals by the Cohesion Policy are Goal 9, "*Industry, innovation and infrastructure*"; Goal 13, "*Climate action*"; Goal 7, "*Affordable and clean energy*"; and Goal 1, "*No poverty*".

Specifically:

- Goal 9, *"Industry, innovation and infrastructure"* is mostly impacted by intervention field 029, *"Research and innovation processes, technology transfer and cooperation between enterprises, research centres and universities, focusing on the low carbon economy, resilience and adaptation to climate change"*, and intervention field 030, *"Research and innovation processes, technology transfer and cooperation between enterprises, focusing on circular economy*".
- Goal 13, "*Climate action", is mostly affected by field 058, "Adaptation to climate change measures and prevention and management of climate related risks: floods and landslides (including awareness raising, civil protection and disaster management systems, infrastructures and ecosystem based approaches)"*; field 059, *"Adaptation to climate change measures and prevention and management of climate related risks: fires (including awareness raising, civil protection and disaster management systems, infrastructures and ecosystem based approaches)"*; and field 060, *"Adaptation to climate change measures and prevention and management of climate related risks: others, e.g., storms and drought (including awareness raising, civil protection and disaster management systems, infrastructures and ecosystem based approaches)"*.
- Goal 7, *"Affordable and clean* energy", is mostly impacted by field 046, *"Support to entities that provide services contributing to the low carbon economy and to resilience to climate change, including awareness-raising measures"*, and field 053, *"Smart Energy Systems (including smart grids and ICT systems) and related storage"*.

- Goal 1, *"No poverty"*, is mainly impacted by intervention field 164, *"Addressing material deprivation through food and/or material assistance to the most deprived, including accompanying measures"*.

By contrast, considering the Goals less affected by the Cohesion Policy, we found that Goal 17, "*Partnership for the Goals*", was impacted the least, followed by Goal 16, "*Peace, justice and strong institutions*", and Goal 15, "*Life on land"*.

3. Results: Applications of the Model to the Sardinia ERDF and ESF 2014–2020 ROPs—The COVID Effect

The proposed methodology, while planned and built specifically for the 2021–2027 programming period, is easily adaptable to the present programs. In fact, the same method was already applied to evaluate the contribution of the Sardinia ERDF and ESF 2014–2020 ROPs toward the SDGs, starting from the financial monitoring data updated to 31 December 2019 and those updated to 31 December 2020.

3.1. Assessing the Contribution of the Sardinia ERDF 2014–2020 ROP

Through its 2014–2020 ERDF ROP, the Sardinia Region addresses important challenges of sustainable development, investing EUR 930 million in the competitiveness of production systems; the protection of the environment and the enhancement of natural, cultural, and tourist attractions; the promotion of social inclusion; and the strengthening of institutional capacity.

The results of the application of the model to the Sardinia ERDF 2014–2020 ROP confirm the vocation of the Programme (Figure 3): it is, in fact, more oriented to certain SDGs, namely Goal 9, "*Industry, innovation and infrastructure*"; Goal 13, "*Climate action*"; and Goal 7, "*Affordable and clean energy*".

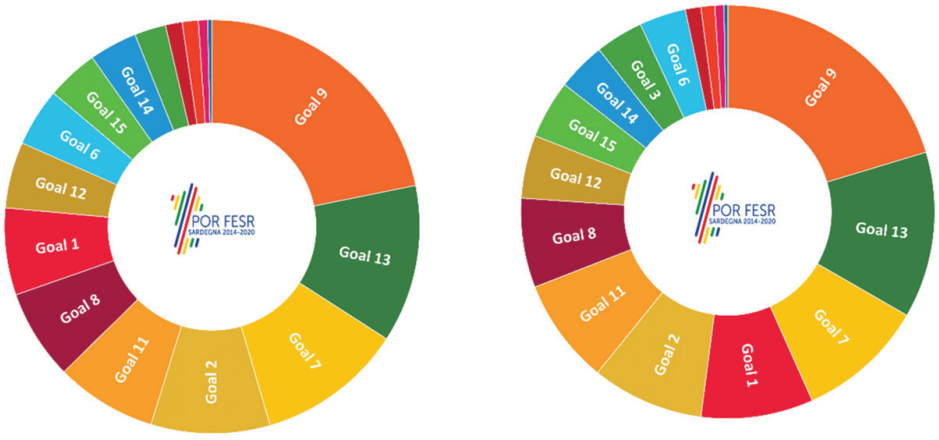

Figure 3. The contribution of the Sardinia ERDF 2014–2020 ROP to the 2030 Agenda SDGs: (**a**) the data here are updated to 31 December 2019 [18]; (**b**) the data here, by contrast, are updated to 31 December 2020 [19].

In 2020, the implementation of the program was inevitably conditioned by the onset of the COVID-19 pandemic. The Managing Authority, thanks to the new regulatory framework launched by the European Union to allow a timely response to the SARS-CoV-2 emergency, was able to redirect resources amounting to over EUR 100 million to the support of actions to combat the crisis, directing them toward the most affected sectors and the purchase of medical devices and equipment. These results are clearly captured by the tool developed and can be seen in the advancement of Goal 3, "*Good health and well-being*", from the twelfth position (Figure 3a) to the eleventh position (Figure 3b).

3.2. Assessing the Contribution of the Sardinia ESF 2014–2020 ROP

The Sardinia ESF 2014–2020 ROP, conversely, with its financial allocation of over EUR 440 million, invests in employment; social inclusion; the fight against poverty, education, and training; and institutional and administrative capacity. The results, again, confirm the purpose of the Programme: the Goals that are most impacted are Goal 4, "*Quality education*"; Goal 1, "*No poverty*"; Goal 8, "*Decent work and economic growth*"; Goal 5, "*Gender equality*"; and Goal 10, "*Reduced inequalities*" (Figure 4).

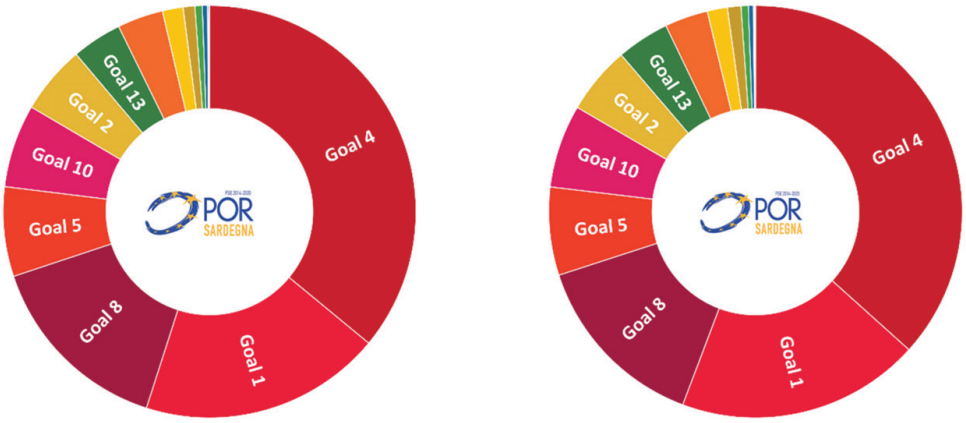

Figure 4. The contribution of the Sardinia ESF 2014–2020 ROP to the 2030 Agenda SDGs: (**a**) the data here are updated to 31 December 2019 [20]; (**b**) the data here, by contrast, are updated to 31 December 2020 [21].

In 2020, the reprogramming process resulted in a total financial rescheduling of over EUR 86 million going toward specific actions and objectives closely related to the COVID emergency. However, given the timing of the implementation of these interventions in 2020, it has not yet been possible to fully grasp the effects in terms of expenditure trends (as, on the contrary, was accomplished for the Sardinia 2014–2020 ERDF ROP). In this case, comparing Figure 4a,b, we found that there were no significant deviations in the results, which thus only confirms the vocation of the Sardinia 2014–2020 ESF ROP. The different applications presented here show how the two ROPs impact different Goals, as they cover different policy objectives within the Cohesion Policy.

4. Conclusions

The research reveals that the Cohesion Policy's investments cannot be a "one size fits all" solution for achieving all the SDGs. Instead, a combination of different financial tools as well as the adoption of non-economic measures, such as regulations and partnerships, are required.

This methodology is a tool capable of capturing the type and number of investments financed by the EU through all European policies that contribute to the SDGs.

Obviously, the support of these investments toward the 2030 Agenda must also be investigated in terms of actual results. Further analysis and evaluation are called for, along with the monitoring of the performance indicators connected to the SDGs and the related data collection.

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Proceeding Paper

Challenges of Indigenous Communities towards Healthy Environments in the Andean Highlands: A Case Study of Conayca, Huancavelica †

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Abstract: A vast number of studies have focused on urban health, but less have focused on rural areas that host indigenous communities. Understanding the different contexts of these communities is key to building healthy environments that are exacerbated in a pandemic such as COVID-19. Additionally, when their population is mainly elderly, the levels of vulnerability and precariousness increase, especially where there is an absence of policies and resources to protect these surviving groups. This research sought to reflect on and critically analyze the social and environmental challenges of these Andean communities in developing healthy environments, such as Conayca, located 3642 m.a.s.l. in the province of Huancavelica, Peru.

Keywords: indigenous communities; healthy environments; Andean highlands; elderly population; mental and physical health; nature-based solutions

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1. Introduction

Social inequality has gained greater visibility in different socioeconomic contexts due to the impact of COVID-19. There are human settlements characterized by deficiencies in the sanitary area, which have become one of the many scenarios of living in a worrying vulnerable state at present. According to the study conducted by the Economic Commission for Latin America and the Caribbean (CEPAL) [1], certain parameters have been identified, such as overcrowding, lack of sanitation and lack of access to drinking water, which make indigenous communities vulnerable areas and, at the same time, a focus of concern in the face of the health crisis.

In the Peruvian context, it is recognized that there are efforts by the central government to support these vulnerable areas as intervention plans of the Ministry of Health (MINSA) [2,3] facilitate the health intervention of regional governments and MINSA; however, the support is truncated. Under this scenario, the community of Conayca, located in the Peruvian Andes (Huancavelica at 3642 m.a.s.l.), has become a field of study of interest, not only because of its inaccessibility, lack of resources and absence of government, but also because it allows us to reflect on the effects of the pandemic on the life of the predominant inhabitants of this community: inhabitants between 69 and 99 years of age.

Considering the characteristics of the inhabitants such as their most common comorbidities typical of their age (gastrointestinal diseases, and malnutrition), their social isolation (they live alone and in a state of abandonment, generating depression) and their labor activity (mainly agriculture and livestock activity), it is important to understand how their direct contact with nature, such as rural areas, greatly influences their wellbeing.

Accordingly, this exploration is based on the impact of the landscape on the mental and physical health of the inhabitants and how nature-based solutions (NbS) can be implemented in rural environments in a state of extreme vulnerability in order to contribute to a better quality of life for the elderly inhabitants, and to prepare for different types of crises (other pandemics) in the future.

Taking NbS as a starting point allows us to re-evaluate the role of ecosystems in the development of a sustainable life and to respond to societal challenges such as the health crisis. A large number of studies confirm the positive impact the natural environment has on the mental and physical health of the user. The quarantine adopted by various societies is evidence of how the everyday environment alters occupants' wellbeing. Therefore, a 10-month period of medical data collection in the study area and recognition of the natural elements characteristic of the rural area allowed for a reflection on how to counteract this current state of vulnerability.

2. Policy Framework

2.1. Relationship of the Human Being and the Environment

According to the Mandala of Health model, a sociological model based on the human ecosystem, the human being is a key part of the wider ecological fabric, operating as an entity within planetary boundaries. It is composed of an interplay between the body, mind and spirit because human values, attitudes and habits are linked to human biology, behavioral trades, psychosocial environments and the physical environment. Therefore, the model of the human health ecosystem integrates the natural and built environments with a dynamic model [4]. Access to public spaces and green areas has been demonstrated to improve mental health and wellbeing. In this sense, landscape design and management solutions that sustain accessibility to parks, gardens, bodies of water, forests and other green spaces promote physical activity and healthier lifestyles [5].

A vast number of studies have reported adverse effects of the built and social environments on health and health determinants through direct or indirect pathways, highlighting the links between the environment and health [6]. In times of the COVID-19 crisis, it is important to understand the integral connection between the environment, health, and the economy [7]. Mental illness is the single cause of long-term medical care, and a major driver of healthcare and other social costs. Thus, when mainstreaming health and wellbeing, people in vulnerable situations such as migrants, indigenous people, children, and elderly people, both in urban and rural areas, must also be considered [8].

2.2. Impacts of the Natural Environment on Health

Human health is part of a global ecosystem, but it also sustains it. Damage to the ecosystem will therefore affect human health worldwide. Thus, to sustain and re-establish ecosystems across the globe, policies must consider ecology and social science as major informants in the process [6]. Considering that disease can be prevented by enhancing the design, creation and management of environments in which people live, many initiatives have been led by the World Health Organization to propose the Ottawa Charter for Health Promotion. This charter contributed to putting health promotion on the international agenda, recognizing that decisions in non-health-related sectors often have an impact on health, and stressed the necessity to build intersectoral approaches to create supportive environments [6].

Climate change's effects on health, social, economic, environmental, and demographic aspects will generate greater impacts on public health [6]. Currently, urban cities, through the living environment, transport, buildings, etc., have impacts on physical health (respiratory and cardiovascular pathologies, trauma), mental health (stress, depression, isolation) and health inequalities (social, environmental, and territorial) [3]. Moreover, public health research suggests that disease tends to take place in those who (a) have fewer meaningful social relationships, (b) are in lower hierarchical positions and (c) are disconnected from their biological and cultural heritages [6].

Likewise, lifestyles in rural areas are also exposed to diseases related to agricultural practices [9]. The most common diseases are diarrheal diseases and Japanese encephalitis. Additionally, due to the management of wastewater for irrigation, intestinal nematode diseases are present [10]. In this sense, the WHO and partner organizations have been developing substantive guidance and providing support for building healthier environments for healthier populations [7]. As part of the WHO's six prescriptions for achieving healthier environments, prescription one is focused on the protection and preservation of nature as the source of human health. This is because individuals and communities derive myriad non-material benefits from ecosystems [11] such as clean air, water, and food. Further, the various cultures, religions and lifestyles in a community must be considered [9].

2.3. Nature-Based Solutions for Healthy Environments

Ecosystems are the support of life on the planet for the human species and all other forms of life [11]. Thus, nature-based solutions (NbS), which are solutions inspired and supported by nature, contribute to enhancing wellbeing and quality of life. However, values related to spiritual or cultural aspects tend not to be valued. Moreover, most of the research conducted has been focused on urban areas rather than rural areas or it has rarely focused on the landscape scale encompassing both rural and urban areas. Therefore, there is an opportunity to understand the values and benefits that nature provides, particularly in rural spaces and at the landscape level [12].

In this sense, NbS play a key role in building sustainable communities to support the development of rural sustainability or the generation of sustainable communities at the landscape level. This is because understanding the ecological and landscape contexts of development can open opportunities for biodiversity [13]. Evidence shows that the more proximity to and experience of nature, the more shaping the values that individuals hold about sustainability challenges and actions and behaviors they should take and perform. Thus, NbS play a role in (1) generating new types of connections of values for nature and, (2) understanding what consequences are taking place in equity terms [12].

3. Methodology

The method used was retrospective, namely, a study based on a database of the local medical center. Thus, the methodology involved the collection of two types of data: First, the data based on the medical visits made by the inhabitants of Conayca were collected. During the interviews, COVID protocols were maintained through the use of masks and appropriate distancing. These interviews were significant in that these individuals not only displayed positive aptitude but also consented to the use of their interviews for academic research. This allowed us to know the diseases and ailments suffered by older adults, specifically those who attended the family medicine clinic, located in the only health post that belongs to the health network of the department of Huancavelica. Second, residents' histories were collected, which allowed us to know their living conditions, their type of housing, their occupation, the number of family members, their customs, their work routines, their knowledge regarding COVID-19, etc.

In this way, both methods contribute to exploratory research, which focuses on analyzing specific aspects that have not yet been analyzed in depth in the Peruvian context. The aim of this study was to find significant patterns in the data to be analyzed so that, based on these results, the vulnerable condition of this type of community forgotten by the government can be clarified and updated. This methodology is the first approach in a vulnerable rural area that invites further research so that it can be directed to a deeper analysis.

3.1. Eligibility Criteria

The community of Conayca has 1219 inhabitants with a population density of 29 inhabitants per km^2. The low population density is due to the constant waves of migration that occur in these rural areas, as the children and grandchildren of resident families prefer to live in cities with better services in search of a better future. However,

older adults prefer to remain in their place of origin even if it means living on their own. Thus, our study focused on diagnosing the wellbeing of elderly Conayca residents living alone in a vulnerable rural community by randomly considering 100 elderly patients due to the difficult access to their homes.

After an approximate general count of the medical visits, it was possible to observe the type of patient according to their age (see Figure 1), where the range was between 69 and 99 years of age. It is understood that they live in a delicate state of health due to their age.

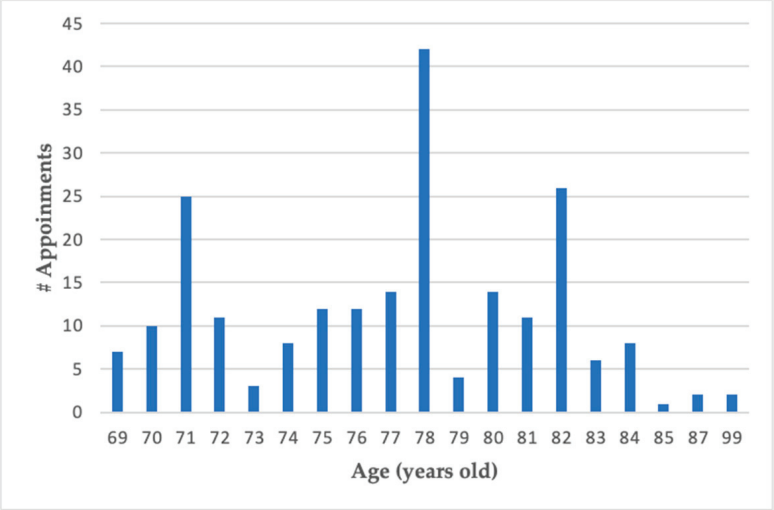

Figure 1. Population age based on a general count of the medical visits. Source: Dr. Cristina Torres-Mallma. SERUMS July 2020–May 2021.

3.2. Information Source and Search Strategy

The medical data collection was conducted by Dr. Cristina Torres-Mallma during her 10-month period of rural and marginal urban health service (SERUMS), under the role of director of the health post located in the community of Conayca. However, faced with the lack of accessibility and disability of some residents, Dr. Torres-Mallma had to go to the patients' residences to conduct some interviews. Although some patients were not as interested in talking to the medical staff, the visits to the homes allowed us to gain a better insight into their daily environment since they are located in remote areas with little accessibility. Each interview took approximately 10 min. Additionally, the interview considered personal data, socioeconomic situation, family history and personal health history.

3.3. Assessment

Since there are no assessment parameters for rural communities located in Latin America, the patterns proposed by the World Health Organization [6] were considered, emphasizing the relationship between the environment and the health status of the inhabitants. Therefore, of the 11 key parameters for healthy cities, communities and towns proposed by Hancock and Duhl [6], we focused on the second parameter which refers to "an ecosystem that is stable now and sustainable in the long term" to explore and reflect on the current situation of the community of Conayca. Likewise, approaches and techniques for community participation in local health and sustainable development developed [14] by the WHO were considered.

4. Results

The results arose by considering three aspects. (1) What is the relationship between the community and the environment? (2) What is the impact of the landscape on the mental and physical health of the members of this community? (3) How are nature-based solutions (NBS) applied to rural areas in favor of the preservation of the identity and belonging of a vulnerable community? The elderly population of indigenous communities needs to be understood in terms of sociocultural, environmental, and economic factors to alleviate the condition of their bodily vulnerability through practices of care that guarantee quality of life not only during pandemic situations [7] but also on a daily basis.

4.1. What Is the Relationship between the Community and the Environment?

For a better understanding, it is relevant to know the inhabitants' profiles. Thus, after collecting medical data and histories for ten months in the community of Conayca, Table 1 shows a profile of the inhabitants of Conayca based on information with a holistic and integrated perspective focusing on the relationships between the social, environmental, and economic factors. The population of this community (average age 69–99 years old) shows a general clinical diagnosis of gastrointestinal diseases and mental health issues. Lack of food essentials and abandonment of family members have been the main causes of malnutrition and depression disorders, respectively. Furthermore, the local government ignores the urgent needs of its elderly inhabitants and promotes practices of (un)care that endanger the health of its inhabitants such as the continuity of festivities without practicing protocol measures.

Table 1. Profile of the inhabitants of Conayca.

Resident	Age	Occupation	Physical Illness	Mental Illness	Rural Environment	Climate
Father	65–99 years old	Farmer/ rancher	Malnutrition	Mild to severe depression	Mountainous area. Presence of hillsides Vegetation areas	Microclimates −1 °C to 14 °C Precipitation Electric storms
Mother	65–99 years old	Farmer/ rancher	Gastrointestinal diseases			

Source: Dr. Cristina Torres-Mallma. SERUMS July 2020–May 2021.

The general health situation of this population is alarming because they are inhabitants who are in a situation of poverty and in total abandonment not only by their families but also by the government. Due to their physical condition and limited accessibility, they tend not to socialize with other members of the community, nor do they manage frequenting health centers to obtain routine health services (see Figure 2). In terms of accessibility, interprovincial public transportation is scarce, and residents have to walk at least 2 kilometers every day if they need to access another town. Furthermore, the pedestrian walkways have been converted into rustic roads that are laid out for the constant use of the inhabitants without any safety measures. Another factor against them is that there is no comprehensive linguistic inclusion, in the sense that sometimes the information and training that come from the central government are neglected when it comes to communicating in Conayca's native language, Quechua. The immediate effect is the lack of interest in health campaigns, training, workshops, etc.

However, their wellbeing depends on agricultural and/or livestock activities. It is observed that this community has an average of three animals per household, which become a source of companionship due to the emotional ties between the elderly and their pets, and a source of food, as in the case of livestock. Likewise, their daily life is dedicated to agriculture as a source of diet. Therefore, the relationship of this community with its environment is limited to being individualistic and for survival purposes.

Figure 2. Medical visits. Source: Dr. Cristina Torres-Mallma. SERUMS July 2020–May 2021.

4.2. What Is the Impact of the Landscape on the Mental and Physical Health of the Members of This Community?

Since human health is part of and depends on the global ecosystem [2], the Conayca community evidences positive impacts on its physical and mental health thanks to the landscape and rural environment. Despite suffering from diseases related to agricultural practices such as gastrointestinal diseases, there are no other cardiovascular, respiratory or endocrinological diseases or other age-related complications. This is because of the physical activity involved in agriculture and the deficient diet, since they only eat a few vegetables such as potatoes but are free of fats, not to mention the dry and cold climate and the absence of air pollution. Furthermore, even if they suffer from depression due to their fewer meaningful social relationships due to family abandonment, the impressive relief of the area characterized by mountains and ravines and the native vegetation of the area (e.g., natural grasses such as ichu, and eucalyptus trees) contribute to the distraction of the mind and mitigation of stress in the elderly (see Figure 3). As a result, Conayca can be defined as a long-lived community, where the landscape and its natural resources are part of an ecological context that shapes the lifestyle by strengthening connections and values with nature through agriculture and livestock. However, it is understood that this is not enough because other factors (i.e., cultural and religious) also influence the integral development of healthy environments.

Figure 3. Rural landscape of Conayca, Huancavelica. Source: Dr. Cristina Torres-Mallma. SERUMS July 2020–May 2021.

4.3. How Are Nature-Based Solutions Applied to Rural Areas in Favor of the Preservation of the Identity and Belonging of a Vulnerable Community?

The community of Conayca shows an idiosyncrasy characterized by a nature-dependent lifestyle in a rugged rural environment with little attention to health, education, and basic infrastructure services. Its economic activity allows the community to value nature only in the sense of harvesting crops and feeding livestock. Although there is respect for

Pachamama or Mother Earth, inherited from their ancestors, cultural practices have ceased to be collective due to personal isolation and lack of accessibility to public spaces (main square) and their own homes. It has also been observed that if the local authority decides to celebrate a festivity, it is carried out without complying with sanitary protocols to avoid COVID-19 contagion. This governance exercise evidences the lack of safety and care criteria for the elderly in Conayca. Faced with this problem, it is considered that the survival of older adults represents a way of integrating NbS into human life, even in very vulnerable and precarious areas. In other words, Conayca has the opportunity to reinforce its link with nature and strengthen its identity as a rural community, since all economic, cultural, social and religious activities revolve around it. Therefore, this contributes to ecosystems where the health of the inhabitants and their environment develop in harmony and stability now and in the long term.

While Conayca facilitates physical health as the environment is free of polluted air and disturbing noises, its exposure to natural hazards such as rain and thunderstorms generates exposure to risks. The lifestyle in Conayca also facilitates mental health because the main mode of transportation is pedestrian, and the main economic activity is agriculture, allowing for daily physical activity and access to healthier food. In addition, the presence of the rural wilderness landscape allows for the protection and preservation of the ecosystem and biodiversity. However, loneliness and family abandonment are decisive factors in the community's mental health. In contrast, health equity represents a challenge because the community's exposure to health risks is exacerbated by the lack of adequate health infrastructure and resources that respond to its wellbeing, as well as the lack of policies and regulations and local governments that consider this vulnerable population. In short, the health and wellbeing of the Conayca inhabitants are local government challenges that exacerbate the incipient awareness to achieve the Sustainable Development Goals and the 2030 Agenda for Sustainable Development.

5. Discussion and Conclusions

From the experience of living with other members of the Conayca community, more questions have been generated since this case represents one of the many socioenvironmental challenges in the high Andean areas of Peru. Although Peru has a national program on age-friendly environments [10], little or nothing is known about indigenous communities. The starting question is, how do we speak of an ecosystem if the population is completely abandoned and isolated by various factors? This leads us to propose a vision of how to strengthen the relationship between community and environment for building local health communities.

The Conayca community's inhabitants represent a vulnerable population because, being elderly, in addition to their health status that is usually more delicate than that of young people, they are not listened to due to governmentality issues (i.e., weak exercise of authority, lack of planning and absence of the voice of the villager). This is why, through this exploratory research, we sought to hear their voices through medical consultations and thus be able to understand their social, cultural and emotional worlds. By raising the voices of these communities, their participation plays an important role in combating social exclusion in Peruvian society. In this way, the results of this research contribute not only to decision making to build appropriate responses, but also to health equity and solidarity in action between indigenous communities, between groups of people of different ages and between genders.

If the government response is slow and resources are limited, there are opportunities to work together with universities and international non-governmental organizations to apply the methods and techniques of the community participation approach in local health and sustainable development. Likewise, the opportunity to have young doctors who choose to carry out the SERUM experience in wild and rural areas for a year is a very significant contribution because their experiences constitute knowledge for public health based on their proximity to the populations and their everyday reality. For this reason,

studies need to be carried out in rural areas where vulnerable populations also reside and who are practically socially excluded, as well as on vulnerable populations in urban areas, to achieve equity in health and dignified lives.

The health of rural communities, such as the case of Conayca, depends directly on the local productive ecosystems that are the sources of basic nutrition, but having a survival lifestyle, they suffer from malnutrition and gastrointestinal diseases. Furthermore, the inhabitants paint a depressive picture due to family abandonment and the absence of affective relationships in their community. For this reason, it is necessary to have some parameters for the Latin American or Andean rural context that are simple to understand and practical in order to avoid procedures and delays so that the residents and leaders can easily organize themselves by integrating the elderly. This allows defining the starting points for principles of spaces adapted to the elderly and indigenous communities based on updated systematic inventories.

A culture of change is needed in the health field, as poverty and the high burden of disease in these communities also impair their ability to prepare for the future. Human wellbeing and poverty reduction also depend on the quality of ecosystems. Likewise, contact with nature, being physical and palpable as well as visual, evidence positive impacts, contributing to the hypothesis that the stimulation of contact with the richness and diversity of ecosystems benefits physical and mental health. Furthermore, in a context of a lack of basic infrastructure, integrating health in urban and territorial planning is vital because it will not only help to achieve SDG 3 (health and wellbeing) but will also strengthen the relationships among the 17 SDGs.

This research provides a strong conclusion in light of the different approaches, methods, models and assumptions, and one that is expected to be relatively unaffected by uncertainties. In this context, by addressing key uncertainties regarding changes in ecosystems and human health, social and environmental challenges towards healthier environments in high Andean areas can provide precision regarding the quantification of the magnitude or times of the impacts, costs, benefits, changes in ecosystems, impacts on human wellbeing or results. Since health and wellbeing for all at all ages are key determinants to achieve the Sustainable Development Goals, the lives of the most vulnerable, such as the elderly in indigenous communities, should not go unnoticed but rather be valued for their role as protectors of rural ecosystems. At the same time, they should be respected as the bearers of cultural identity. By improving human health and wellbeing, the Conayca inhabitants will foster resilience and continue to protect the environment.

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Proceeding Paper

Connecting Innovative Eco-Entrepreneurship Model and Sustainable Nature-Based Solutions to Advance Climate Action, Biodiversity and SDGs †

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Abstract: The state of climate emergency threatens oysters, which are species that provide immense development–environment benefits in the world's coastal regions, including the global south. Currently, extreme climate change combines with toxic chemicals to alter ecosystem services by 70%, resulting in oyster decline, habitat shifts, school dropouts, poverty and ecological job loss. This poses complex transformative challenges for the UN Sustainable Development Goals (SDGs). In response, GreenOyster Opportunities for Development (GOOD) integrates a GOOD Eco-Entrepreneurship Model (GEEM) into oyster conservation as a Sustainable Nature-based Solution (SNbS) for providing food and scientific ecotourism services. This article succinctly elaborates the GEEM-SNbS concept and theory of sustainable change in favour of the SDGs and to inspire in-depth research into SNbS financing, new carbon policies and reframing biodiversity conservation and sustainability actions.

Keywords: sustainability; eco-entrepreneurship; GEEM; SDGs; SNbS; oysters; climate action

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1. Introduction

The UN Sustainable Development Goals (SDGs) are optimistic foresights for good Anthropocene futures [1,2] and, as such, must be publicly defended, sustainably financed and politically reactivated. It is not surprising that the urgency to achieve the SDGs, within the next 10 years, to unleash sustainable well-beings to reach everyone is becoming competitively intense among nations through the SDG indexing [3]. Although the roadmap to realise SDGs is still open, the journey to the 1.5 °C world envisioned by the Paris Agreement is full of polycomplex socio-ecological and legal setbacks mainly attributable to the overheating of the Earth's climate (sub-)systems, about which scientists, experts and climate activists have given repeated warnings [4–9].

The tragedy is that over 6000 published studies revealed that the outcome of climate mitigation ambitions from all nations amounted to 52–58 $GtCO_2eq\ yr^{-1}$ by 2030, which would not 'limit global warming to 1.5 °C' [10] (p. 18). As revealed by the Club of Rome, IPCC and researchers, the atmospheric CO_2 at 400 ppm is over the limits and has irreversibly damaged the planetary boundaries [11] and global and regional economies [12,13] in excess of US$11 trillion [14]. The World Economic Forum predicts the extinction of 200 species annually and the loss of 10% of GDP due to climate disasters in the US before the 21st century ends [15], and The Economist indicated a dangerous destabilising of Amazon biodiversity assets across tipping points [16]. Also, carbon-induced instability has exacerbated social vulnerabilities, insecurities and inequalities [14,17], which are inversely driving sustainable development [18,19]. An increased search for a remedy raises the importance of nature-based solutions for realising the SDGs [20,21].

In rapidly peri-urbanising savanna coastscapes of West Africa [22] and vast corridors of the world's coastal regions, including North America, India and the Arabian Gulf [23,24],

meeting 100% of the SDG targets to usher in sustainable futures is not possible without utilising climate-smart and nature-based solutions to wisely harness, enrich and sustain coastal bioresources, especially oysters. Oysters provide substantial restorative environmental benefits by removing nitrogen [25,26], thus, enriching reef habitats [27] and the daily filtering of 100–200 litres of water [28]. The harvesting and trading of oysters constitute a booming industry that furnishes food, employment, shelter and socio-cultural needs. Oysters are medicinal and nutritiously rich in protein, amino acids, Vitamin B12, magnesium and zinc [24,28–31] for combating acute malnutrition (SDG#2).

Balanced oyster diets (SDG#3) saved the lives of impoverished children who could have starved or died during COVID-19 mandatory lockdowns. Extreme climate change combined with the high utilisation of toxic chemicals considerably to alter ecosystem services by up to 70%, resulting in reduced oyster populations, ecological job loss, poverty, child labour and youth migration. At times, no oysters are harvested, thereby, limiting livelihoods [32]. Local divers often see dead oysters washed offshore (Figure 1b). In some communities, oysters have either gone extinct or migrated to deeper hydrospheres.

(**a**) (**b**)

Figure 1. (**a**) Freshly harvested oysters ready for head-carriage to a local market. (**b**) A scene of dead oysters washed offshore observed through a rapid action on an early morning at 7:45 a.m. (GMT) at Agorta Bay, near Soga City in the Lower Volta Basin.

Despite the fact that oysters have been academically studied for various scientific reasons—for example, being a vector for alien species [33], salinity [34], nitrogen reduction [35], usage as an ancient tool [36]—the sustainability and eco-entrepreneurship sides of the oyster value chain have been grossly neglected. The eco-enterprise mindset is muted about this in the literature and policy.

Recently, the GreenOyster Opportunities for Development (GOOD) integrated a GOOD Eco-Entrepreneurship Model (GEEM) into oyster conservation as a Sustainable Nature-based Solution (SNbS) to provide food and scientific ecotourism services to meet varying sustainability needs. GOOD's uniquely dynamic approach involves introducing green energy technologies and a carbon compensation scheme, digitalising and transforming the oyster economy, recycling oyster shells and rolling out a Community Sustainability Improvement Savings and Loans (CSISL) to connect local beneficiaries to a Sustainability Learning and Improvement Platform (SLIP).

In navigating the GEEM-SNbS theory of sustainable change, this paper uses realistic information from rapid action engagements, start-up actions and preliminary observations from the estuary of the Volta River in Ghana to outline the challenges, prospects and strengths associated with an enterprising SNbS start-up that integrates GEEM. New opportunities for enabling the GEEM-SNbS to intervene in climate emergency (SDG #13), poverty (SDG#1) and biodiversity loss (SDG #14 and #15) to accelerate massive socio-ecological improvements are highlighted, including trailblazing the computation of the sustainable capital value (SCV) of cash valued species (CVS) through CSISL. This stimulates

understanding, future research into the GEEM-SNbS nexus, SNbS financing and sparks fresh discourses into how GEEM can strategically refoster science–business–academic partnerships (SDG #17) towards maximising SNbS for sustainability and SDGs.

2. GEEM-SNbS Concept and Theory of Sustainable Change

In pre-industrial era, conservation was conceived as one-sided with no regard for sustainability. However, as the significant science of sustainability continues unstoppably rising [37,38] and the pressurised mission to achieve SDGs is mounting, the notion of conservation is changing universally. Now, the approach to biodiversity conservation and other nature-based solutions should be three-dimensional in order to be responsible, profitable and sustainable; where sustainable means all the three key components of sustainable development described in the Brundtland Commission Report are heeded and carefully streamlined into designing, planning, implementing and evaluating actions.

Here is where the GEEM-SNbS theory of sustainable change advantageously comes in. As brilliantly defined in [39] (p. 1), nature-based solutions are 'solutions to societal challenges that involve working with nature'. This easy-to-understand definition does not entirely differ from the meaning of the SNbS. In the sense of sustainability, the interest in SNbS is not only about the extent nature-based projects can lessen climate impacts or repair damaged nature but also in innovatively tapping income from within and for Extremely Low-Income Communities (ELICs) to sustain implemented SNbSs.

The GEEM model, published [poster format] by the Nature-based Solutions Initiative based at the University of Oxford in July 2020 (see Figure 2), is conceptualised and meticulously packaged to function on the premise of a "sustainable value chain" of species with an existing cash value in deprived rural areas, informal settings and communities emerging from natural disasters, pollution, locust invasion, hazards, displacements, climate conflicts and humanitarian emergencies. Since the species in question are cash valued, the (in)direct emissions of greenhouse gases (GHGs) either through transportation, manufacturing or land-use is inevitable.

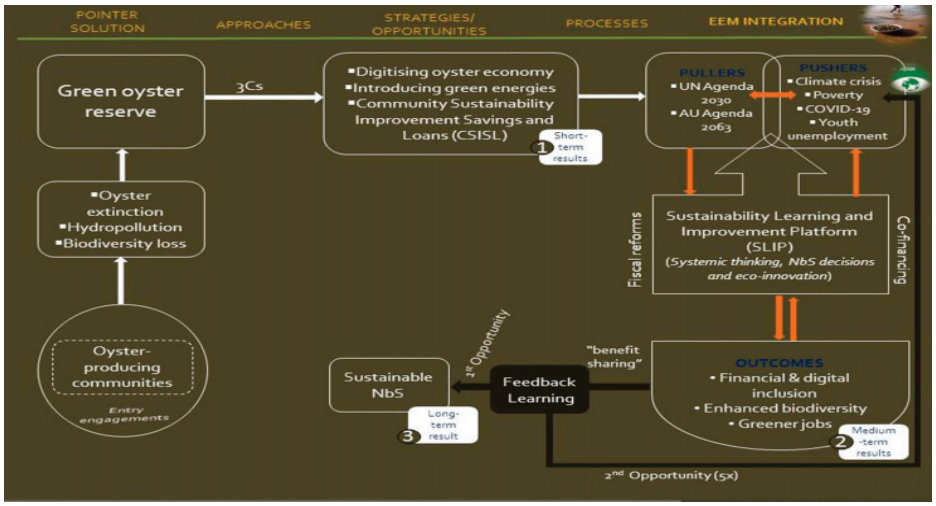

Figure 2. A diagram of the GEEM-SNbS nexus.

As a result, this model is formulated with a community-based oyster reserve as a pointer solution in mind for greening oyster ecologies, industries and empowering ELICs to minimise extinction, GHGs and to decouple microplastic pollution from oyster production and consumption. GEEM works by mobilising local resources, groups and institutions to implement varied interventions, including shifting attention from biomass energy to prevent mangrove deforestation. GEEM triangulates the SNbS knowledges generated from the SLIP to inspire active participation in oyster conservation, SDG action, awareness creation against child labour and the removal of microplastics from estuaries.

Normally, biodiversity conservation and other green projects at the grassroots level depend 100% on external funding. Most of the external project-based finances may be too restrictive or suddenly removed [40] as recently suffered under the period of COVID-19. The coronavirus pandemic negatively affected the sustainability of SNbS on the ground. Among countless challenges, a 'lack of finance is widely recognised as one of the main barriers to the implementation and monitoring' of nature-based solutions globally [41] (p. 8). Contextually, the GEEM is motivated to scan, diagnose and change this situation by removing barriers to create conducive conditions for local beneficiaries of SNbS to self-raise and spend at least 2% of net profit through a well-structured CSISL and associated sustainable investments to co-finance, sustain and own 'green shares' in conserved ecosystem services.

The central requirement of the model, therefore, is that the beneficiaries must be capable to earn income from a supportive ecosystem in sustainable means. In other words, a functional GEEM must generate greener revenue to create sustainable prosperity for all. GEEM is suitable for fauna and flora species that already have cash value (see a brief exposition in Section 3.3) in the natural or organically cultivated agri-environmental systems.

The examples of CVS are Theobrama cacao, Mangifera indica, Vitellaria paradoxa, Manihot utilissima, Anacardium occidentale, Elaeis guieneensis, mangroves, Citrus spp., tillapia, cotton, Cocos nucifera, Musa spp., Oryza sativa, snail, crab and shrimp. Hunting or harvesting of any species legally declared a crime is excluded. GEEM can also be applied in aggregate renewable ecosystems (i.e., combination of species in heritage and RAMSAR sites, parks, etc.) that support paying for ecosystem services, such as ecotourism. This means that the GEEM is replicable in marine and mixed terrestrial ecosystems at different places.

The model does not promote conservation by conventionally held business-as-usual wisdom. For that reason, GEEM relies on the sum of eco-innovation, system rethinking and SNbS decision-making interlinking 3Cs approaches (conservation, co-restoration and consumption) as explained in Table 1. The eco-innovation blends best practices, human values, digital technologies and new sciences through SLIP to enable primary and secondary beneficiaries to learn, decide and act on the sustainable use of oysters.

Table 1. GOOD 3Cs approaches.

3Cs Approaches	Understanding the Processes
Conservation	Conservation means enriching, conserving and protecting oysters and their ecosystems, including water and immediate land resources to increase and sustain benefits for people.
Co-restoration	Co-restoration means inclusive engagement and sustainable empowerment of all actors, social groups and authorised leaders for rehabilitating and repairing destroyed oyster habitats.
Consumption	Consumption means using low-carbon methods and technologies to commercially produce organic oysters, greenly process and distribute fresh oysters, shells and other by-products through approaches that are not harmful to human health and the coastal environments.

Source: Author.

3. Sustainability Learning and Improvement Platform (SLIP)

GEEM drives best on an immersive learning and practising wheel called SLIP. SLIP is a pivotal heart of the GEEM innovation. It creates a rotational circuit that function 24 h within the GEEM framework to reconcile and deal with trade-offs, risks and gamut of socio-planetary boundary issues ranging from extinction, child labour, gender inequality, behaviours, benefit-sharing to conflicting synergies until sustainability improves and synchronises across systems, institutions and sectors to move forward the SDG agenda. Here is where the SLIP highlights changing contents, evidence and services of the SNbS to be thoroughly discussed and assessed and therein ensures that confusions are clarified to repel disinformation about conservation issues, beliefs and bylaws. How to support child labourers back to school and to prevent future school dropouts are collectively deliberated.

A stronger basis why seeding trust, soft and positive human values among beneficiaries is treasured by SLIP component of the GEEM.

The key reasons underlying SLIP are to improve relationships between humans and nature, expand opportunities, nurture cooperative spirit and identify system change needs for incorporating in empowerment and coaching of individuals and youth groups with less capacity to efficiently integrate *Brundtland principles* into implementing low-carbon livelihoods and oyster conservation activities. The activities are intended channels to bring-in better well-beings and to network with and mentor young actors to actively participate in oyster habitat enrichment—for example, replanting mangroves. To succeed, SLIP provides new skills, competencies and instruments to equip beneficiaries to become agents and stewards of the oyster ecosystems.

This is done by gathering appropriate knowledge from indigenous and scientific domains and translating this into meaningful actions [42], such as boosting oyster restoration. For strengthening social inclusivity, women and diverse actors regain their voices from the SLIP learning subspaces to freely exchange new ideas and inventions with scientists, leaders and all actors on pressing climate matters, prices, access to finance or input regulations. In the exchange processes, helpful tools could be adopted to monitor and evaluate oyster conservation progress. Thus, SLIP relies on organically blended layers and levers of sustainability strategies and actions (see Figure 2) to enable SNbS to intervene in biodiversity, climate and COVID-19 crises.

The SLIP allows for the transfer of greener energy technologies and friendly web tools to transition from fossil-fuel to renewables, promote good health, digital inclusion and literacy in support of the six major transformations and the six social tipping interventions comprising norms and values necessary for realising the SDGs and Paris Agreement [4,18]. (Re-)setting goals regarding real-life issues is the shared responsibility of the participants in the CSISL and SLIP, which permit peer-learning and aligning the GEEM services to all the 17 SDGs.

3.1. Community Sustainability Improvement Savings and Loans

CSISL is an add-on savings and lending strategy of the GEEM targeting over 4500 oyster processors (women), retailers (girls) and divers (men) in the initial phase. The major feature that differentiates CSISL from other local financial networks is the sustainability criteria added at the SLIP—for instance, SNbS decisions and removal of emissions from land-uses. Another merit is that the CSISL flexibly insists on low-carbon sources of incomes. In practice, the CSISL promotes only SNbS services, which are deliberately designed for decarbonising the oyster economy and fostering the transition out of all land-use GHG emissions, broadly estimated between 2007–2016 to be '12.0 $\pm$ 3.0 Gt CO_{2e} yr^{-1}, includes CO_2, CH_4 and N_2O' with a 'net emissions of 5.2 $\pm$ 2.6 Gt CO_{2e} yr^{-1}' from deforestation [41].

CSISL was tried on a microscale with US$ 1000 (Lended Amount—LA) that remarkably yielded 89.5% Actual Recovery (AR) success within an agreed 180 days at GEEM Interest Rate (GEEM IR) of 5% (see Figure 3) as compared to an Open Market Interest Rate (Open Mt IR) of over 25% in the first half of 2021. Once sustainability has improved, it is expected that the 5% interest rate will further reduce [43], thereby, enabling more people, predominately vulnerable women to emerge out of SDGs #1 and #2. The remaining 9.5% of the loan was retrieved after 6 months.

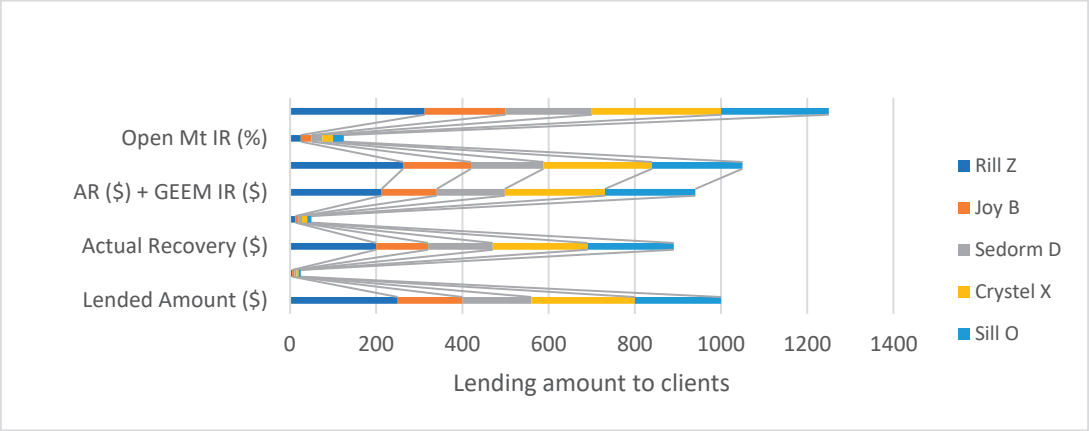

Figure 3. CSISL recovery outlook.

3.2. CSISL Grand Challenges

The CSISL was confronted with three top risks that tilted smooth piloting. First, the deadly COVID-19 pandemic shattered client engagements and field monitoring. Secondly, unstable microclimatic conditions spirally triggered by the West African monsoon disrupted water flows at the downstream of the Volta River that led to reduced oyster catch, thus, weakening the financial capacity of divers to willingly contribute to the CSISL. Thirdly, organising focus meetings as enshrined in the *green codes and ethics book* of the SLIP was halted because the oyster value chain was not digitalised to ease communication. Thus, digitalising the indigenous oyster economy was proposed and fed into feedback learning and backcasting (see Figure 1).

3.3. Determining Sustainable Capital Value (SCV)

SCV is imperative for assessing the extent that SNbS action can meaningfully improve the lives of people by reducing poverty and hunger and by helping CSISL members to mobilise finance to fully or co-run SNbS services. This is a strong basis for why it is advisable that the species underlying the SNbS action must have a cash value if the GEEM is to be successful.

$$\begin{aligned} \text{SCV (Aggregate)} &= \$SG_p \times C_1 \times C_2 \div (\text{RLC i.e.GH¢}/5.2) \times 12 \\ \text{SCVx Individual (Annually)} &= \text{SCV} \div (C_1 \times C_2) \\ \text{SCVy Individual (Monthly)} &= \text{SCVx} \div 12 \\ \text{SCVz Individual (Daily)} &= \text{SCVy} \div 30 \\ \text{Final value} &= \text{SCVz} \times \$1.25 \end{aligned} \quad (1)$$

where SCV = sustainable capital value; C_1 = number of CSISL members known here as 30, which ideally cannot be less than 20 due to operational and other costs initially; C_2 = number of CSISL groups, which is known here as 150; and RLC = recapitalised local currency, which is represented here as GH¢5.2 = $1 for Ghana. For other countries, substitute the GH¢).

To calculate a SCV, a Green Share Price (GSp) must be chosen in US$ to reflect the cash value of the species in question. The GSp should be equivalent to an amount a beneficiary is likely to invest in SNbS as a "share" (here, an Oyster Reserve). For example, to obtain GSp for oysters, $2000 was chosen. How much can it take to reduce poverty and, at the same time, help the CSISL members to give a token (an accruing "GSp") towards securing and sustaining an oyster reserve towards an ultimate goal of conservation?

The GSp must be recapitalised in a local currency for X, Y and Z values if an individual beneficiary subscribe to the CSISL and SLIP. Using Equation (1), the result of the GSp (i.e., $2000) gives a SCV in local currency as GH¢12.82. The GH¢12.82 must be multiplied by $1.25 to internationally standardise at $16.03, which is higher than the international poverty line and the national minimum daily wage of many developing countries. In

all circumstances, the final value for SCV must be positive, advisably higher than the international poverty line to be acceptable. A negative SCV is not advised.

3.4. GEEM-SNbS Start-Up Prospects for SDGs and Futures

- GEEM can enable 4500 divers, processors and retailers (i.e., 150 CSISL groups) to mobilise US$3,994,082.85 annually to co-finance oyster conservation assets.
- GEEM enables recycling of 1250 metric tonnes of oyster shells for utilisation as substrates in manufacturing eco-friendly products to enhance resource use efficiency.
- GEEM encourages deployment of renewable energy technologies to increase access to affordable and cleaner energy in the ELICs. It decouples air pollution and mangrove forest degradation from oyster value chain by shifting beneficiaries' focus from burning fuelwood and charcoal to solar energy. Thus, GEEM fights deforestation to boost biodiversity and is, thus, compatible with the REDD+ and biodiversity treaties.
- GEEM can deliver SDG and conservation messages to reach 1.5 million people.
- GEEM can support 600 divers to produce 1.68 billion organic oysters by 2030, translating into 300 decent jobs and an expanded green-blue economy.

3.5. Opportunities for Future Research

1. Assessing and responsibly digitalising the oyster economy to become a commercially inclusive and capable to accelerate biodiversity information sharing.
2. Researching how sustainable eco-entrepreneurship, legal and financial market regulations can be positively leveraged to aid fiscal flows and choices by the SNbS start-ups. How can youth-led SNbS start-ups access and transparently utilise funds?
3. Investigating the potential of GEEM in empowering SNbS start-ups to financially transform beyond pitching for $1000 into vibrant institutions capable to support the SDGs and other developmental agendas, such as the UN Convention on Biological Diversity.
4. Re-examining parameters for calculating SCV (see Equation (1)) for cash-valued species to inform scientific definition, planning and reframing conservation actions.

4. Concluding Remarks

The power of eco-entrepreneurship in enabling SNbS to be responsive and sustainable should not be undervalued. In this sense, the degree to which eco-entrepreneurship can decarbonise and transform the oyster value chain ought to be clearly comprehended and recognised in the context of the actual sustainable change needed to achieve the SDGs, poverty eradication, biodiversity richness and carbon neutral economies. Such a recognition should reflect the fact that a sustainable change is not an ordinary change. It is a nonlinear system change that exhibits precise characteristics of *Bruntland principles* or sustainability whether in the short, medium or long-term.

Thus, in connecting eco-entrepreneurial decisions through SNbS to sustainably conserve oysters within the larger coastal landscapes, the financial, social and environmental modes for turning around system change towards sustainability must be equally prioritised. GEEM illuminates this character by redefining and promoting sustainable finance of climate solutions, SDGs and ensuring consistent flows of financial and ecosystem services. While further investigation into how GEEM-SNbS can lead to long-term sustainable change and the sustainability of large-scale SNbS is strongly recommended, this model is relevant for incentivising and galvanising international public–private partnerships and sustainability actions from and for ELICs to catalyse socio-environmental transformation.

This is envisioned as a rapid transformation driven by science and partnership that continually supports the functioning of oyster ecosystems in greener and eco-inclusive manners for SDG advancement and sustainability. The striking sustainability milestones of the GEEM were its success in (i) raising the gender equality ratio in oyster conservation from zero to 60% in 1 yr and (ii) creating public awareness of oyster conservation, SDGs and extending socio-ecological sustainability knowledge to reach over 50,000 people. In sum, this article shines light on the GEEM-SNbS theory of sustainable change by re-echoing

that the model is indispensable in mobilising people and connecting eco-entrepreneurial innovations to successfully implement oyster conservation and SNbS towards advancing local and global efforts to achieve SDGs, biodiversity and climate action in sustainable ways.

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Proceeding Paper

Africa GreenCo and the Independent Off-Taker Model: Beyond 'Single-Buyer' Power Markets and Uncreditworthy Utilities †

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Abstract: Africa GreenCo is challenging the existing model of how new private-sector-funded grid-scale power is brought online. By introducing the first non-government-owned buyer of renewable energy in sub-Saharan Africa—a region with few creditworthy public utilities—GreenCo will act as a bankable counterparty for independent power producers. The company aims to catalyse private investment and boost the growth of additional clean generation capacity in support of climate change mitigation, adaptation, and energy access. The paper reviews modelled investment- and climate resilience impacts.

Keywords: electricity access; IPP; Southern African Power Pool; climate resilience; SDG 7

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1. Introduction

Africa GreenCo (GreenCo) is introducing the first independent (non-government-owned) buyer of renewable energy in sub-Saharan Africa (SSA). GreenCo will act as a creditworthy counterparty for independent power producers (IPPs) to support the growth of additional generation capacity.

Currently, the majority of the utilities in the region are publicly owned and face significant financial and other challenges, which constrain their ability to expand and maintain good-quality power services [1].

GreenCo is challenging the existing model of how new grid-scale generation is brought online, which is currently reliant on a single offtake arrangement between a public utility and infrastructure developer. Where the regulator has put in place a feed in tariff or auction structure, a power purchase agreement (PPA) will be set up. This ensures that the dollar rate per kilowatt hour paid to the developer is fixed for the economic life of the asset. The state entity will commit to 'take or pay', and, typically, the government is required to guarantee the PPA of the public utility (in part or full) to make the entire transaction bankable. In the case of non-payment by the public utility to the IPP, the sovereign guarantee is activated, and the government commits to cover the financial obligation. In SSA, the process of structuring and implementing PPAs repeatedly fails, mainly due to the poor creditworthiness of the public utilities and national governments [2].

For the private investor, financing a project with an uncreditworthy counterparty comes at a high cost, which, when combined with technology and macro risks, may explain the spreads observed in the discount rates of renewable energy (RE) infrastructure projects in developing and developed economies (see Ref. [3] on heterogeneity within each group). To reach financial close, the range of project risks will have been allocated, mitigated, or transferred in a way that satisfies all stakeholders [2]. This process has presented a unique set of challenges for RE projects in developing economy contexts, where PPAs are regarded as cornerstone instruments and poor PPA quality undermines the investment rationale.

Alternative measures to mitigate counterparty risk, such as liquidity support instruments, early termination buyout regimes, and partial risk guarantees, do exist, but they are complicated and expensive to negotiate on a project-by-project basis. Where they are implemented, such instruments do not fully capture the perceived risk of these fixed asset investments. They are, likewise, heavily reliant on concessional capital and support from development finance institutions [4]. The literature also raises important political economy questions vis-à-vis traditional derisking interventions, such as sovereign guarantees, which socialise the investment risk among the taxpayers of the developing economy, while the commercial benefits of the project are reserved for private investors [5,6]. In markets where GreenCo acts as an independent off-taker, the requirement for sovereign guarantees will be reduced or removed.

The following pages consider the impact of the Africa GreenCo business model in addressing the limitations associated with the single-buyer model in the region's power markets, particularly as they relate to the aims of the Paris Agreement and relevant energy and climate sustainable development goals (SDGs). Specifically, these are a shortage of investment and insufficient diversification of energy sources in the region's fuel mix.

2. Insufficient Investment

2.1. The Challenge

Africa needs a decade of significant investment into low-emissions-intensity and climate-resilient power infrastructure to meet the high watermark of the SDGs and other electricity access and electricity 'greening' initiatives: Goal 7 of the SDGs targets universal access to clean, modern, and reliable energy by 2030; Goal 13 calls for urgent action to combat climate change and its effects; the Paris Agreement aims at a reduction in greenhouse gases to limit global warming to well below 2 degrees centigrade; Agenda 2063 of the Africa Union targets both a 50% increase in electricity generation and distribution, and for 70% of Africans to have access to electricity by 2023 [7]. These initiatives are commonly employed as the basis for a pro-investment case, particularly in renewable energy, in which coalitions of capital, with a prominent role for the private sector, are to bankroll the spending necessary to acquire infrastructure and deliver energy access along sustainable pathways.

A number of assessments are doubtful regarding the outlook for achieving these targets [8–10]. Investment has failed to scale to the heights of policy intentions. However, with the right level of finance, it would be possible to install 310 gigawatts (GW) of clean renewable electricity—roughly 40% of the continent's current total electricity generation capacity—to meet nearly a quarter of Africa's projected energy needs by the end of this decade [11]. To achieve this would require average annual investment of USD 70 billion until 2030. Yet, annual clean energy financing across SSA reached around a tenth of that figure in 2018, at USD 7.4 billion [12]. Some 56% of that sum went to South Africa, the continent's second largest and arguably most advanced economy.

Several macroeconomic and microeconomic challenges are given to explain the shortage of public investment in the power sector. At the macro level, for local governments, access to finance through sovereign debt raising—a typical method for raising public infrastructure finance—is constrained by poor credit ratings across SSA (and, thus, a high cost of borrowing on international markets) and subdued local capital market development [13]. Debt distress, which was a feature of many African economies prior to the economic catastrophe of the COVID-19 pandemic, significantly weakens the borrowing potential of Africa's sovereigns. Considering the costly response to the pandemic, the African Development Bank estimates that the average debt-to-GDP ratio in Africa is expected to increase significantly to over 70%, from 60% in 2019 [14]. The corollary is a tightening of fiscal space in the public sector as debt interest payments rise—making a dire fiscal situation worse. In 2018, Southern African Power Pool (SAPP) members were paying 33% more in debt servicing as a percentage of gross national income than the average across sub-Saharan Africa. In single-buyer markets, when added to the fiscal constraints of

sovereign guarantees, the above range of factors combine to create a 'sovereign ceiling' for public power sector investment and public enablement of private investment.

At the micro level, there are also issues of governance and the (mis)management of public finances, which complicate or impair the public response to infrastructure development challenges. Primarily, public utilities have struggled to integrate break-even or profitable business models. One key challenge is the provision of service below cost, which has the added complication of being tied up with government policy orientation. A 2016 study by the World Bank [1] discovered that, across electricity utilities in 39 countries in SSA, only the Seychelles and Uganda were achieving full operational and capital cost recovery, while as few as 19 successfully generate revenues to cover operating costs. As an indicator of financial ill-health in the sector, quasi-fiscal deficits (QFDs) (i.e., the revenue–expenditure gap of the public utility company) averaged 1.6% of the GDP across SSA, according to the study, and exceeded 3% of the GDP in several countries [1,15]. Based on data from the same study [15], the situation is most acute in southern Africa, where QFDs as a share of the GDP among the members of the SAPP are 140% higher than the next most indebted regional power sector (Table 1).

Table 1. The SAPP has the widest quasi-fiscal deficits across Africa's power pools.

Power Pool [1]	% GDP
Central Africa	0.62
East Africa	0.87
West Africa	1.46
Southern Africa	2.07

[1] Data source: Ref. [15]—where country data were available.

In Zambia, for example, executives at the state-owned power company, ZESCO, like their regional counterparts, have faced pressure to cap consumer tariffs, while inadequate revenue collection processes undercut their ability to make back the cost of supplying electricity [16]. Nearing the peak of its fiscal crisis and sovereign default, Zambia's finance minister conceded that foreign currency arrears incurred by state-owned enterprises were weighing on the sovereign balance sheet. The aggregate amount at the end of June 2020 was approximately USD 1.29 billion, nearly 6% of the GDP in 2019. This balance comprised guaranteed and non-guaranteed sums, mostly incurred by ZESCO, through arrears on power purchase agreements [17]. At a sufficiently grand scale, then, the use of implicit subsidies arising from under-pricing and ineffective (or non-existent) metering and billing practices can create financially unsustainable losses that contribute to systemic fiscal weakness and undermine public investment [18]. However, at the company level alone, financial disarray within state-owned utilities limits their ability to credibly enter contractual arrangements with private sector players that would develop new power plant infrastructure.

2.2. GreenCo Impact

As discussed, the financial unviability of SSA's utilities remains a significant constraint to private investment in electricity generation. Among the SAPP countries (Angola, Botswana, Democratic Republic of Congo, Eswatini, Lesotho, Mozambique, Malawi, Namibia, South Africa, Tanzania, Zambia, and Zimbabwe), where GreenCo will focus its operations, a 2017 master plan document, the SAPP Pool Plan, identified at least USD 121 billion worth of generation capital expenditure (capex) in the period to 2040 (2017 net present value (NPV); the estimate accounts for regional demand projections, national energy security considerations, and trade between countries (referred to as the 'Realistic Integration Scenario')) [19]. GreenCo estimates that, of the additional capacity earmarked for commissioning between 2017 and 2019, some 55% did not materialise, measured in megawatts (MW), and approximately 20% had failed to reach the commercial financing stage (based on assessing a sample of projects). An analysis of academic and grey literature supports the GreenCo view that PPA quality is determinative in investment decisions and

likely lies behind a substantial portion of these failed investments. A qualitative analysis of the projects that have not come online in that time also indicates a growing threat to large coal-fired power plants, approximately 1GW of which appears to have been shelved or stranded and a further 2.5+GW has been delayed with significant cost overruns and legal challenges.

Governments within the SAPP are aware of the difficulty of coaxing private investment and forecast that 74% of additional capacity in the next 3 years will have to be publicly financed [20]. Using that figure across the cost projections (2022–2040) of the SAPP Pool Plan's 'realistic integration scenario' (a planning-software-based scenario optimised against real-world constraints), GreenCo estimates roughly USD 20 billion (2022 net present value) in IPP investments will be needed to meet the demands of the regional master plan. This is a conservative estimate as the ratio of private to public finance in generation capital expenditure will likely narrow. Assuming a 35% contribution to generation capex from the private sector in the period of 2030 to 2040, the demand for commercial investment rises to USD 24 billion (Table 2).

Table 2. Implementing the SAPP Pool Plan will demand significant private investment.

Private Investment Requirement '22-'40 (USD bn)	
Low	High
19.6	23.8

Author's calculations with data from Ref. [19].

The perception of GreenCo as a creditworthy off-taker is critical to the operating strategy and sustainability of the business model. The effect of GreenCo's creditworthiness is a lower cost of capital for IPP developers, which, even after a margin is added, still delivers lower wholesale electricity tariffs for PSA off-takers. One approach to clearly demonstrate GreenCo's creditworthiness to financiers of the IPP is to ensure that its capital structure includes a guarantee base sufficient to cover the commercial debt lent to IPPs in its PPA portfolio, and an equity base to act as a liquidity buffer. This liquidity buffer will enable GreenCo to exercise its risk mitigation strategies (in the event that the PSA counterparty defaults) and even incur some losses in the process without utilising the capital allocated to cover commercial debt [4].

Based upon its modelled portfolio (2021–2031), GreenCo will deliver 2.5 GW of greenfield renewable energy to the SAPP region at an estimated total investment cost of USD 4.7 billion. The use of DFI debt finance to guarantee commercial lending is an option in the early stage but would fall as a portion of IPP costs over the period. Private capital mobilised by the GreenCo model is estimated at USD 2.7 billion (Figure 1), a contribution of between 11.5% and 14% to total private investment in the SAPP (2022–2040). To put this in perspective, GreenCo's modelled contribution is more than four times (400%) the forecasted investment of all the SAPP countries across non-hydro renewables in a comparable time period (2022–2031, 2017 NPV) in a 2017 'pre-masterplan' stated policies scenario. With successful implementation, GreenCo's model would make a vital contribution to realising (and, in some cases, stretching) the region's investment objectives.

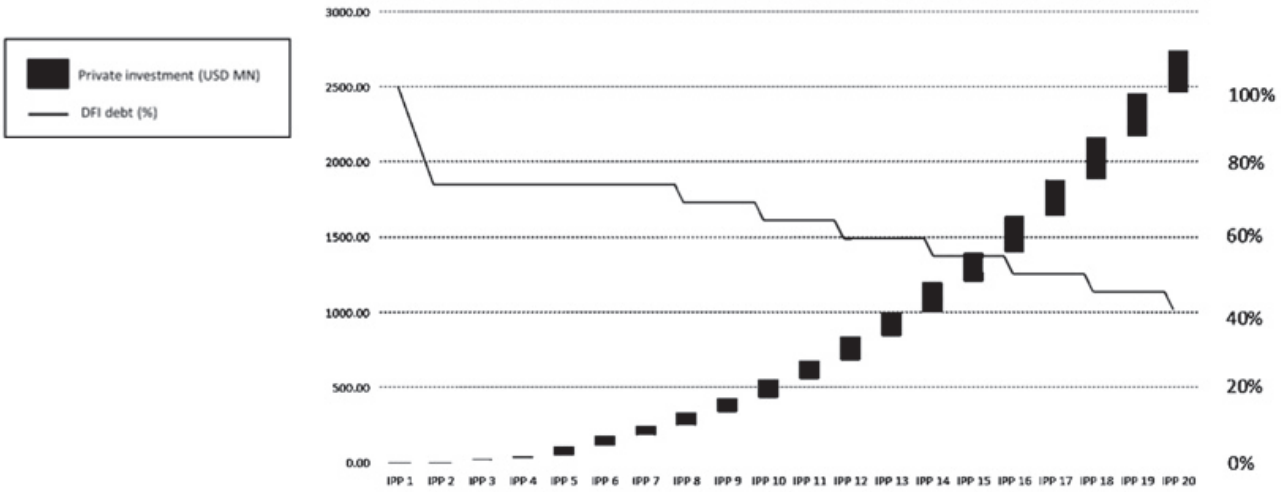

Figure 1. Private IPP investment across GreenCo modelled portfolio.

3. Climate Resilience

While the direct climate change mitigation impacts of an RE portfolio such as GreenCo's are significant, they are also well understood by a wide audience and easily calculated using standard methodologies. Instead, GreenCo's potential impact on the climate resilience of the SAPP is the focus of this section.

3.1. The Challenge

Africa's economies are ill-equipped to contend with their 'maximum vulnerability' to the effects of climate change and climate shocks [21]. The continent's high population growth, overreliance on subsistence agriculture, high water dependency for power, and low fiscal capacity to respond to shocks constitute a state of high climate-related exposure and low resilience.

National climate vulnerability is generating greater systemic risk for the power sector in SSA. Of the eleven SSA nations with a more than 50% dependency on large hydro (>50 MW), six are SAPP members (Angola, DRC, Malawi, Mozambique, Namibia, and Zambia) and make up 20% of the installed capacity in the SAPP. El-Niño-induced droughts, predicted to occur more frequently as average global temperatures rise, mark this reliance as climate vulnerability [22]. The region's national utility companies are cash poor and typically unable to adapt fully in the face of lost capacity. SAPP data show that Angola, Botswana, the DRC, Malawi, South Africa, Tanzania, and Zimbabwe all had installed capacities greater than their peak demand in 2016, yet they all experienced capacity shortfalls in that drought-stricken year [22]. In such cases, diesel back-up capacity and emergency imports come at a great cost (and with higher emissions). As a result, utilities resort to 'load shedding', brownouts, and blackouts to manage the allocation of a scarce resource. According to a model published by the World Bank, for a handful of hydro-dependent nations in SSA, the use of emergency power obtained by expensive short-term lease due to drought can increase utility deficits by more than 1% of the GDP in certain scenarios [15]. The case, briefly outlined in the introduction of ZESCO in Zambia and the droughts that derailed the utility and the economy, is a cautionary tale [16].

Among several southern African nations, the electricity supply is overly dependent on the water levels in the Zambezi basin [23]. However, an assessment of adaptation and vulnerability published in 2014 by the Intergovernmental Panel on Climate Change forecasted that the region can expect harsher and more frequent droughts in the coming decades [16,23]. Another review suggests that the Zambezi hydropower output could decline by 10 to 20% under a drying climate [24]. Arguably, for these riparian states, hydropower's techno-economic advantages of being cost-efficient and flexible have negative

returns to scale at high levels of dependency, raising questions about the suitability of pursuing greater electricity access through heavy investment in large-scale hydro [25].

In pursuit of the Paris Agreement aims and energy security, there is a need to improve the share of other RE sources in the energy mix, such as solar and wind. Evidence suggests that the current policy pathway is at odds with this stance. In southern Africa, for example, 89% of the new hydro capacity is planned for the Zambezi basin [26]. While not all the areas of the basin are equally drought-prone, the trending hydroclimatic unpredictability is not compatible with the current policy outlook.

One way to explain this policy inflexibility in the face of incremental downside risk is the idea that energy transitions are not purely technical but also socio-political. Unlike entirely technical or techno-economic transitions, socio-technical transitions often encounter multifaceted headwinds that disadvantage movement away from incumbent technological structures [27]. At an intuitive level, with dominant technologies comes an expensive and painstakingly established architecture of skills and training institutions, inelastic regulatory and technical capacity within energy ministries and utilities, and existing upstream and downstream infrastructure with associated jobs. The academic literature also points to the evidence of 'lock-in' effects of dominant technologies in the energy mix. Semieniuk and Mazzucato [10] show that financing flows and specific sources of finance create innovation pathways as certain technologies are deployed, proven, and de-risked, resulting in a lower cost of capital in subsequent projects. Ahmed [22] considers Zambia's commitment to large hydro infrastructure, even following droughts in 2015, 2016, and 2019, and suggests a deep ('third degree') path dependency now exists that is based on initial conditions (such as early financial support for hydropower from multilateral development banks) and ignores new information that implies course correction is required. Important political economy dynamics are thought to contribute to lock-in [28,29].

Whether path dependency encroaches more directly in markets with a dominant single player is unclear. It is plausible, however, that multiple actors with a wider pool of capital and stakeholders, and a broader array of strategic objectives, might behave less uniformly and be capable of delivering power generation infrastructure that contributes to greater diversification (including diversity of scale) and climate resilience.

3.2. GreenCo Impact

A comparison of portfolio energy mixes (GreenCo forecast portfolio versus SAPP forecast additional capacity) shows an equal split among solar PV, wind, and small-hydro in GreenCo's indicative portfolio (2021–2031) compared to a substantial addition of large hydropower capacity across the SAPP based on the masterplan projections (2021–2031). However, as discussed, it is right to account for the outsized effect of dominant technologies on market concentration and possible future dependency. The empirical evidence is supportive; there are few historical cases of developing economies that have charted a path out of hydro-dependency. By adopting the Herfindahl–Hirschman Index (HHI), typically used to measure market concentration as an indicator of competition, we can more appropriately capture the significance of dominant technologies. A similar approach is used by Rubio-Varas and Muñoz-Delgado [30] in conceptualising their Energy Mix Concentration Index (EMCI). The HHI method takes the sum of squared market shares for all energy sources in an economy in period (t).

Adapted from their work:

$$\mathrm{HHI_t} = \sum_{i}^{t} x_i^2 \quad (1)$$

where x_i is the percentage share of the energy source i in the energy mix. Smaller values of the HHI indicate greater diversification [30]. Table 3 below proposes two dynamic SAPP EMCI scenarios: (a) SAPP Pool Plan capacity additions in the 'realistic integration case' 2021–2031; (b) SAPP Pool Plan capacity additions in the 'realistic integration case' with GreenCo capacity additions, 2021–2031. The simplifying assumptions are an equally weighted split of GreenCo's additional 2.5 GW across solar PV, small hydro, and wind, and

an equally weighted displacement of new fossil fuel and large hydropower capacity across the period. In each case, the HHI is calculated. As a point of reference, the HHI for SAPP's existing stock of generating assets (2018) is 4190, with coal being the dominant technology (60% share of the energy mix) [20].

Table 3. GreenCo's RE portfolio improves fuel mix diversification in the SAPP.

Energy Source	SAPP Additions '21-'31 (MW)	SAPP + GreenCo Additions '21-'31 (MW)
Natural gas	4766	3933
Coal	1502	669
Hydro small	890	1723
Hydro large	14,025	13,192
Solar thermal CSP	100	100
Solar PV	120	953
Wind	155	988
Total	21,558	21,558
HHI	4788	4192

Evidently, continued and significant investment in large hydro is built into the current SAPP masterplan projections. The data show that, with GreenCo's contribution to new capacity, SAPP can see a slight improvement in the diversification of capacity additions, but, in both cases, the concentration of hydro is high. In terms of emissions reduction, however, the fall in new coal capacity in the GreenCo-impacted case is a positive indicator. Focusing policymakers' attention on the concentration impacts of additional capacity (i.e., ΔHHI) in 5-to-10-year periods, for example, may help to improve the accountability of investment decision-making and align the narrative of climate-resilient power infrastructure more closely to the policy cycle.

Beyond fuel mix concentration, another indicator for resilience is capacity utilisation in various climate scenarios. Emerging from the recent literature are useful quantitative starting points for further climate modelling. As Ahmed notes [22], there are nearly two decades of forecasting that point to harsher and more frequent drought and low reservoir levels in the Zambezi basin, with clear direct impacts for hydropower capacity factors. As a possible benchmark, comparing 2014 and 2016, the average capacity utilisation rate fell from 71% to 54% across Zambia's four large hydropower dams as drought struck. Spalding-Fecher and others [24] consider the impact of electricity generation costs due to wet and dry climate in the SAPP region. Across SAPP, they estimate that increases in electricity generation costs are circa $10 billion—representing less than 1% over the long-term but unevenly distributed geographically and in terms of time horizon. Zambia and Mozambique could see hikes of up to 35% in long-term generation costs, being the hardest hit, and as much as 20% in the near-term [24].

Historical performance data of hydropower assets alongside hydroclimatic data will improve the modelling potential to develop a clearer picture of climate resilience in region-specific RE portfolios, as well as in cases where markets are interconnected via power pools and an improvement in the climate resilience in one country has positive network effects. The SAPP Pool Plan makes a useful start in this direction, as does the work of Spalding-Fecher and others [24]. In the medium-term, GreenCo will contribute to this area of research to draw attention to the positive impact that non-traditional electricity market participants can make.

4. Conclusions

The paper has focused on GreenCo's systemic impact as an enabler of RE investment and its ability to contribute to a more diversified and climate-resilient regional fuel mix in the future. GreenCo will act as an independent off-taker in the SAPP region, entering into

sound, bankable, and long-term PPAs with IPPs and securing a diversified pool of energy buyers, whether on a bilateral basis or through short-term local and regional trading.

Ample evidence exists to uphold counterparty creditworthiness and PPA quality as critical determinants of private investment in a single-buyer market. Addressing the 'sovereign ceiling' and the financially onerous approach of the existing derisking instruments, the GreenCo intervention demonstrates a pathway of evolution for the regional power sector beyond the flaws of its current structure.

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Proceeding Paper

Feasibility Study for a Black Sea SDGs Observatory †

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Abstract: This paper presents the outcomes of the project titled: ''Feasibility Study for a Black Sea SDGs Observatory", financed by the Black Sea Project Promotion Facility. The project was assigned to the Aristotle University of Thessaloniki and the Financial University of Russia. The Observatory will constitute one of the main divisions of the regional UN SDSN (United Nations Sustainable Development Solutions Network) Black Sea. The paper presents the need for establishing a Black Sea SDGs (Sustainable Development Goals) Observatory, the methodology followed, and the expected results of its creation.

Keywords: SDG monitoring; sustainable development goals; Black Sea

1. Introduction

During the COVID-19 crisis, the necessity of timely, high-quality, open, and disaggregated data and statistics was never more apparent. Such information is crucial for understanding, managing, and reducing the pandemic's human, societal, and economic consequences. They are also necessary for developing short-term reactions and action plans to get countries back on track to meet the SDGs.

COVID-19 responses are significantly limited due to many of the data problems observed during the first five years of SDG implementation. The lack of basic health, social, and economic data is one of them. To make matters worse, the crisis is affecting normal operations across the global statistical and data system, delaying scheduled censuses, surveys, and other data programs.

Members of the statistical community have quickly responded by adapting and inventing data production methods and processes to assure operational continuity. Investments and support for data innovation are urgently needed, according to various assessments of

statistical operations around the world. These will aid policy responses to the crisis, as well as initiatives to accelerate SDG progress over the next decade.

It is a pivotal period to advance a shared vision and speed up remedies to the world's most pressing problems, from ending poverty and hunger to reversing climate change. The rapid spread of the novel coronavirus, however, turned a public health situation into one of the worst worldwide crises of our lives, forever altering the world as we know it.

Now, the COVID-19 pandemic has quickly become the worst human and economic crisis of our lifetime, spreading to all countries, with the global death toll exceeding 500,000, and the number of confirmed cases at more than 10 million people.

"As Member States recognized at the SDG Summit held last September, global efforts to date have been insufficient to deliver the change we need, jeopardizing the Agenda's promise to current and future generations", quoted UN Secretary-General António Guterres. "Now, due to COVID-19, an unprecedented health, economic and social crisis is threatening lives and livelihoods, making the achievement of Goals even more challenging." [1]

This annual stocktaking report on progress toward the 17 Goals, based on the most recent data and estimates, shows that the poorest and most vulnerable people—including children, the elderly, people with disabilities, migrants, and refugees—are the ones who are most affected by the COVID-19 pandemic. Women are also bearing the heaviest brunt of the pandemic's effects.

In the context presented above, the Black Sea Project Promotion Facility (BSPPF) funded the project titled: ''Feasibility Study for a Black Sea SDGs Observatory'', after the successful application submitted by the Aristotle University of Thessaloniki and the Financial University of Russia.

The Observatory will constitute one of the primary divisions of the regional SDSN Black Sea', and will serve as a hub for the promotion of the UN SDGs in the countries of the Black Sea area.

This paper intends to communicate this initiative to the scientific community and to solicit assistance from authorities, specialists, and agencies in the Black Sea region, which will be required at the next and most important step, which will be the Observatory's real funding and operation.

2. Methodology

The need to achieve sustainable economic development meets a range of common challenges, and the effort to mitigate the consequences of climate change can provide powerful incentives for joint action in a regional format. These should be exploited in order to generate complementarities within which economic cooperation at a regional level may develop despite the many divergences and different priorities of the states in question.

The principles of sustainable development should be the guiding philosophy of regional cooperation in the Black Sea area. The Black Sea area is depicted in Figure 1.

At present, there is no well-timed prompt relevant report on the socio-economic state of the Black Sea countries issued on a permanent basis.

The monitoring center reveals the potential changes of the current processes and signals to the authorities to undertake the necessary measures in the region that could contribute to sustained and inclusive economic growth; which, in turn, can drive progress, create decent jobs for all, and improve living standards.

Figure 1. A map with the countries of the Black Sea area.

The methodology adopted for the Feasibility Study includes the following steps:

- The current reporting patters of the different Black Sea countries will be identified using, as a main source, countries' voluntary reports;
- A comparative analysis will be held which emphasizes the deviations (reporting alignment index) of SDGs reporting patterns across countries;
- The Architecture of the Black Sea Observatory, as well as the procedures and the algorithms regarding data handling, will be presented. Moreover, the conceptual model and its main functions regarding the Observatory's monitoring system for the data handling will be analyzed;
- The composition of necessary spaces for the headquarters of the Observatory will be described;
- Definition of activities of the relevant directorates and units of the Observatory;
- The financial sustainability of the Observatory, as well as its Business Plan and Future challenges, will be discussed.

3. Expected Results

The project's final output, titled the ''Feasibility Study for a Black Sea SDGs Observatory'', will address the following areas: (i) existing data sources related to the calculation of the SDGs in the Black Sea Region, (ii) the lack and need of data and the contribution of the Observatory, (iii) the Observatory's objectives and goals, and (iv) challenges in the Observatory's establishment.

3.1. Existing Data Sources Related to the Calculation of the SDGs in the Black Sea Region

All of the Black Sea Region countries need to collect data from various sources in order to calculate their SDGs and monitor the current status of their country. Each country collects data from both national and global organizations. A reliable source of data is the United Nations organization with historical data for each country, as well as the reports conducted from both the UN [2,3] and the SDSN [4,5]. Of course, each country can utilize their National Statistical Agencies, which collect a huge amount of data throughout the year.

Additionally, other potential sources can be found in sector specific data and information from ministries and other authorities, as well as through data from sector specific

policy documents which involved specific performance indicators. A variety of information can be collected from businesses and other stakeholders through meetings and discussions, which is often necessary for better understanding of underlying issues.

3.2. The Lack and Need of Data and the Contribution of the Observatory

As mentioned in the previous section, each country collects a huge amount of data. However, many of the SDG indicators in each country are empty, and as a matter of fact, they cannot be assessed. Thus, the Observatory will be observing, registering, assessing, combining and analyzing the latest available data relevant to climate action, and the sustainable use of resources and society regarding the countries participating in the Observatory. Through data analysis, it will identify strengths and weaknesses regarding the practices followed for the collection and evaluation of the data by the national authorities of the participating countries. Furthermore, after creating a satisfying database, the Observatory will be able to suggest new methods, new techniques, and/or new indexes that might help the statistical authorities observe and describe fundamental information regarding the needed data or that might lead to better data registration. To be successful, the Observatory will be in constant communication with national and international authorities who register relevant data.

3.3. The Observatory's Objectives and Goals

The objectives and the goals of the Observatory are manifold and can be summarized in the following points.

The Observatory has the potential to contribute to the development of knowledge regarding sustainable development and to make the SDGs Black Sea region Observatory a world-class level centre in science and education. It can also encourage the development of innovative and efficient services that meet the needs of many potential users (public or private sector). Additionally, a stronger link between research and education, as well as the private sector, can be established in order to create more jobs by laying the groundwork for long-term development through increasing economic competitiveness.

Furthermore, the Observatory can increase the interest of graduates in specific scientific fields, fostering a more focused specialization, and assist in addressing societal challenges in a variety of fields covered by the Sustainable Development Goals (poverty, hunger, quality education, affordable and clean energy, industry, innovation and infrastructure, among others) in the Black Sea region. Moreover, it can strengthen and enhance the Black Sea region research area by developing more efficient international research systems and ensuring strong transnational collaboration through open access and transformation of knowledge.

Last but not least, by promoting a research environment on themes related to sustainable development, the Observatory can reduce possible brain drain in specific areas and/or scientific disciplines across the Black Sea region, convincing scientists and students not to transfer somewhere else.

3.4. Challenges in the Observatory's Establishment

Although the establishment of an SDG Observatory in the Black Sea region is a promising and a robust step in the measuring of the SDG implementation performance, that will give better insight regarding the countries of the Black Sea region, several challenges remain, that need to be tackled to effectively deploy and operate the Observatory.

One of the main challenges is getting in touch with the offices and the institutes that currently monitor the implementation of the Sustainable Development Goals in each country. Within the scope of the preliminary report [6], we have tried contacting the people referenced in the Voluntary National Reports (VNRs) [7] and the National Statistical Institutes of each country, but very few responded. As a matter of fact, few countries have appointed certain officers that are tasked with observing and monitoring sustainability.

Therefore, identifying and communicating with specific people that are needed to aid in the Observatory's establishment remains a challenge.

Moreover, National Statistical Institutes and Offices will be needed to share their data with the Observatory. This might run into several obstacles, as some Governments might not be favorable in sharing their countries' statistics and data with an international and multi-national organization, as the Observatory will be.

Finally, the establishment and operation of the Observatory for the first few years will require funding. Thus, a major issue that needs to be addressed is the source of funding and whether it will be constant, for instance in the form of an annual subscription of the National Institutes of Statistics to participate or not.

3.5. Benefits of the Observatory's Establishment

The benefits of research and policy infrastructures, such as the Black Sea SDGs Observatory, are not easily captured, due to the diversity of potential projects that can be undertaken. New enterprises, such as such as start-ups and spin-offs, for example, may use the Observatory's data to improve or evolve their services. Large corporations involved in research and providing services related to smart, sustainable and inclusive growth, relevant research infrastructures and/or competence centers in collaboration with universities or other companies, may also benefit from the development of innovative products and services based on the Observatory's work. In general, the establishment of the Observatory will be a positive externality for the private sector.

The Observatory will also aid in the applied research of researchers, academics and young professionals, while they will also benefit from the contemporary scientific literature that is expected to be published. Furthermore, the training of undergraduate, postgraduate and PhD students could be enhanced by activities related to the actions of the Observatory.

The innovative research and the monitoring methods that are expected to be developed in the Black Sea SDGs Observatory will assist in cost reduction related to big risks, such as climate change effects, extreme natural catastrophes, etc.

Moreover, the regional impact of the Observatory's establishment is expected to be major from both a monetary and non-monetary perspective.

High quality personnel will be attracted by the operation of the Observatory, contributing to the enhancing of the social capital of the Black Sea region and the overall improvement of the quality of both academic research in general and the institutions that participate in the Observatory's initiatives.

The integration of SDGs in the domestic policies of the Black Sea countries will be easier and more effective after the establishment of the SDG Observatory, which will optimize the process of tracking and integrating the SDG indicators by tracking and analyzing the best and most effective practices implemented among the participating countries, after taking into account aspects that impede sustainable development. In addition, timely monitoring of the main drivers and data aggregation for SDGs through the Observatory could positively affect further development of the Black Sea region.

4. Discussion and Conclusions

Monitoring the implementation of the Sustainable Development Goals is a crucial step for achieving the targets set by the Agenda 2030 for inclusive and equal societies, that respect and secure human rights and ensure the lasting protection of the natural resources and the planet. Efficient monitoring requires suitable data and the use of advanced data analysis techniques to fully describe the progress towards sustainability in a country or a region.

Taking into account that the region consists of many states with various similarities and differences, that share the fragile ecosystem of the Black Sea, the need for data and region-specific reports is imminent to achieve sustainability. Thus, the establishment of an Observatory tasked with following the implementation of the SDGs and aiding the relevant states for improved data collection is necessary.

The Observatory will comprise a database which will be organized as a collection of structured information on SDGs dynamics in the region, through which a systematization and presentation of SDG data via easily accessible periodical reports will be achieved. Consequently, potential effect of the Observatory on the Black Sea region includes:

- Forehanded information update, by mapping the already existing research, innovation and technology in the Black Sea region, using an interactive platform, aligning them with the SDGs and developing a set of regional policy and entrepreneurial priorities.
- Key issues identification by country. Policy makers of each country will be able to assess the extent to which policy objectives have been fulfilled and provide a basis for identifying strengths and weaknesses and making necessary adjustments in their national policy and government programs.
- Best practices and practice recommendation list, providing the member states with a sophisticated analytical tool containing the best practices followed by country and how they could be implemented.
- Investor attraction. Quantitative indicators of SDGs are highly effective in drawing attention of business regulation, identifying priorities for cooperation, communicating success and progress. Thus, the operation of the Observatory will aid in the attraction of foreign direct investments in the Black Sea region.
- Collaboration hub. The Observatory will be a main factor of collaboration by promoting regional linkage, intra-regional bonding and globalization of local economies through regional and international cooperation.
- Educational hub. The Observatory's operation will stipulate educational programs and training programs for the staff and relevant parties. Its educational function is expected to increase the level of socio-economic culture of the whole region, preparing highly qualified specialists and promoting the development of public diplomacy.

Of course, the establishment of an international organization faces many challenges, such as establishing cooperation with the National Statistical Offices and Institutes, gaining the trust of the relevant states, and ensuring funding for the first years of operation, but the advantages of establishing an SDGs Black Sea Observatory overweigh the aforementioned challenges, as its creation is a major step forward towards implementing sustainability in the Black Sea area.

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Proceeding Paper

Fostering Sustainable Development in Tseltal Terms †

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Abstract: This article draws heavily on my PhD thesis (as the last reference), which was published after the ICSD 2021 conference took place. The study investigates how local traditional knowledges are informing Indigenous women entrepreneurs (IWE) in promoting sustainable economic development in their communities during the 2020–2021 Covid-19 pandemic. The research is grounded in Indigenous guided participatory approaches with collaborators/participants from six Tseltal communities located in Chiapas, Mexico. The research findings offer deep immersion into the critical aspects of Tseltal knowledge, including environmental, social, cultural, and economic dimensions. These aspects leverage local capacity in developing *sHachel jwohc' a'tel* (Tseltal entrepreneurship initiatives) while enabling opportunities for gender transformative collaborative work and *sna'el ya'beyel stuc te bin ay ma'yuc* (Tseltal economic development grounded in community wellbeing).

Keywords: sustainable development; Tseltal knowledge; Indigenous entrepreneurship; gender transformative approaches; community-based participatory action research

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1. Introduction

The term Indigenous Entrepreneurship is relatively new in scholarship even though Indigenous Peoples have pursued what is understood as "entrepreneurial initiatives" for hundreds of years. The concept "entrepreneurship" has been documented across multiple disciplines since the 1800s and its mainstream terms and definitions usually include aspects of decision-making and management in terms of resources, opportunities, value generation, and success assessment [1]. However, the understanding of common concepts such as "resource", "wealth", "value", and "success" may drastically differ depending on the local context, especially if the context is Indigenous. Entrepreneurship is heavily influenced by entrepreneurs' culture, it "should not be defined on the basis of opportunity, but rather cultural perception of opportunity" [1] (p. 3). Indigenous peoples have distinct cultures and knowledges, so it is possible to assume that there are as many definitions of Indigenous entrepreneurship as Indigenous communities currently pursuing entrepreneurial initiatives. Recent studies on the topic have identified a few points of alignment among Indigenous entrepreneurship's initiatives, such as the inclusion of non-economic explanatory variables, environmentally sustainable practices based on traditional ecological knowledges (TEK), and governance structures based on kinship ties [2]. Based on these points of alignment, many definitions have emerged highlighting core characteristics such as the fact that the creation, management, and development of such ventures are undertaken by Indigenous people for the benefit of Indigenous people. Indigenous entrepreneurship initiatives can pertain to either the private, public, or non-profit sectors generating a broad range of desired benefits, from economic profit for a single individual to the broad view of multiple social and economic advantages for entire communities and their stakeholders [3] (p. 132).

An essential aspect in constructing the definition of Indigenous entrepreneurship across scholarship is that several authors agree that it critically involves the participation of Indigenous peoples, the ways they see the world, and their distinct knowledges [3]. However, even though Indigenous knowledges (IK) and worldviews have a critical role in this

field, their relevance has not been systematically investigated [4]. This gap in scholarship can be due to the difficulty of conducting research and writing about IK using Western methodologies and colonial languages. The meaning and understanding of Indigenous concepts can drastically change when interpreted by non-Indigenous peoples [5]. In the face of this, many Indigenous authors have explored common characteristics across Indigenous cultures and explain that they share a few grounding principles: traditional knowledges that are holistic, cyclic, and connected to everything; acknowledgement of many truths that are dependent upon individual experiences; understanding that everything is alive and that all things are equal; the sacredness of their lands; and the importance of their relationship with the spiritual world, among others [6]. In the context of Indigenous development and entrepreneurship, Peredo and McLean identify three universal characteristics of Indigenous cultures: collective or communal orientation, inclination to a kin-based social structure, and their preference to consider social and cultural aims as being at least equally as important as material gains [7] (p. 605).

Understanding the value of relationality from Indigenous perspectives can be helpful in studying how Indigenous peoples transform and adapt the practice of entrepreneurship by providing utmost equal importance to land, community, and relations (both social and spiritual) with all beings. In fact, some authors argue that relationality (interpreted as embeddedness) "can be a motivator that triggers entrepreneurship" [8] (p. 2). This suggests that in investigating topics related to Indigenous entrepreneurship, researchers must be prepared to observe complex terms and practices in which meanings adjust and change depending on the locations, values, traditions, and histories of the specific entrepreneurial ventures studied. Since these ventures are heavily influenced by Indigenous worldviews—which are distinctive, fluid, and holistic—the methodologies used to conduct studies in this field must align with these characteristics. In addition, researchers are encouraged to acknowledge that, in translating practice to written theory in colonial formats, layers of complexity are likely to be omitted. This study integrates these methodological aspects and aims to understand how the participant Indigenous communities undertake sustainable development projects through the work of Tseltal women in their entrepreneurial initiatives. It was undertaken with the participant communities to collaboratively document and analyze the constructs of their local knowledges and practices in addressing the economic challenges of their communities. The results can potentially contribute to finding points of alignment between Indigenous knowledges and Western approaches to sustainable development that advocate for increasing community wellbeing along social, cultural, economic, and environmental dimensions.

2. The Study Context and Methodology

This study was undertaken in the Municipalities of Ocosingo and Chilón, in Chiapas, Mexico. In this territory, 80% of the population identify as Tseltal, one of the main Maya cultures of this region [9]. Among many of the Maya contributions to the advanced understanding of math, linguistics, astronomy, and philosophy are the concept of the number zero, the most sophisticated system of writing of their time combining ideograms and phonograms, complex studies and calculations used to accurately predict the movement of the planets and stars, architecture innovations such as domes, arches, and wide interior spaces, and sophisticated governance models [10–13]. One of their most popular works is the *Popol Wuj*, which reveals "the K'iche' authors' sagacity and creativity in their struggle to defend the memories, knowledge, and values of their people tenaciously" [14] (p. 3).

Until this day, many Maya peoples keep tirelessly contributing to the assertion of their culture and keep resisting and defending their autonomy in a context that has historically ranked in the last position in the Human Development Index for the last hundred years [15]. According to the last poverty report by the National Council of Social Development Policy Evaluation, 94% of the population of Chiapas lives in a situation of vulnerability, poverty, or extreme poverty [16]. Recent studies have revealed that one of the main reasons for the current state of vulnerability in Chiapas is the increasing rates of food insecurity related

to sociodemographic characteristics and low-income factors [17,18]. This situation refers mainly to the drastic decrease in the production of food for self-consumption which has impacted the economic income of Indigenous families, allowing the penetration of cheap industrialized foods with high fat and carbohydrate content [19]. The situation is directly contributing to the progressive abandonment of traditional healthy practices, such as the preparation of handmade tortillas and the cultivation of local greens and vegetables, among other local foods. Currently, Chiapas is the largest consumer of beverages and soft drinks with high sugar content, which mainly affects Indigenous children, youth, and the elderly population by increasing their risk of suffering morbid obesity, diabetes, and cardiovascular diseases [20]. In the face of the pandemic caused by COVID-19 during 2020, the level of risk of the Indigenous communities in this territory increased due to the lack of access to health services, clean water, and sanitary products.

The associated nonprofit organization of this research study, IXIM AC, is one of several organizations and initiatives in this region that are focused on addressing issues of malnutrition and food security. Currently, a network of 15 Tseltal communities' representatives, collaborating with IXIM AC's team and stakeholders (such as fieldwork coordinators, nutritionists, agricultural specialists, engineers, academic researchers, and committed individuals from funding agencies and other NGOs), coordinate efforts in promoting local entrepreneurial projects. The communities' representatives, traditionally called *jTijaw*, are Tseltal women that are community promoters, organizers, and leaders working as volunteers by popular demand in their communities. The *jTijaw*, their groups, and IXIM AC's fieldwork coordinators are the 133 participants that are collaborators and co-researchers in this study.

The research was designed and undertaken using a unique participative approach grounded in the collaborators/participants' practices, perspectives, and knowledges. The collaborators/participants guided and collaborated in all the research activities using interchangeable roles, from planning the research, including its scope and design from June 2018 to March 2020, to data gathering, analysis, results systematization, and knowledge mobilization from April 2020 to March 2021. By incorporating values and methods from community-based participatory research (CBPR) [21], Fals Borda's approach for participatory action research (PAR) [22–24], insurgent research principles [25], and Indigenous grounded theory (IGT) [26,27], the data were gathered and analyzed by the collaborators/participants through traditional orally based processes of collective knowledge creation in the shape of collaborative workshops in their communities led by the *jTijaw* and organized by IXIM AC's fieldwork coordinators. The participants' interchangeable roles are described as follows:

- 128 participants: 113 Tseltal people organized in six groups led by 15 community promoters or *jTijaw*.
- 20 participants and co-researchers: 15 *jTijaw* and 5 IXIM AC fieldwork coordinators. According to their roles in this study, these 20 people are organized into two teams:
    1. The IXIM AC research team (IRT), comprised of 21 participants including the 15 *jTijaw*, the 5 IXIM AC fieldwork coordinators, and the author of this paper (Me in Figure 1) as lead co-researcher. The 15 *jTijaw* were participants but also performed duties of data gathering through voice recordings, language translation, and IK interpretation distinctive for each of their communities for this research. At the same time, their work as participants was documented in voice recordings by the five IXIM AC fieldwork coordinators.
    2. The systematizing team (ST): composed of six people including the five IXIM AC fieldwork coordinators and the author of this paper as lead co-researcher. The five IXIM AC fieldwork coordinators are considered participants of this study because their perspectives and experiences working with the *jTijaw* and their groups in the six Tseltal communities were considered as part of the data. However, they also collaborated in the gathering, cultural and language translation, coding, and

analysis of the data using traditional orally based methods following the IGT methodology [26,27].

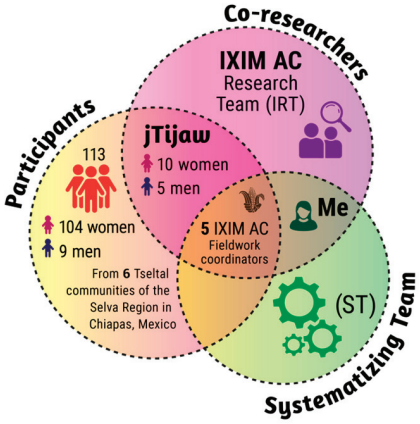

Figure 1. Participants and co-researchers.

An explanatory graphic of the interchangeable roles of the participants and co-researchers is presented in Figure 1.

Among the findings from this research, it was identified that this study's unique methods used in the collaborative workshops and grounded in orally based practices integrate core elements of Indigenous research methodologies that are grounded in the commitment to empower the participants to address their communities' needs [28].

3. Results

The co-creators/participants of this research perceive that for Tseltal community well-being or *buhts'an qu'inal* to exist, it is essential to attend to the holistic, all-encompassing wellbeing of all the community's individuals. Each Tseltal individual's wellbeing transcends to the wellbeing of their families that create and generate their sense of community. The participants/collaborators of this study identify this three-dimensional interconnection between the individual–family–community as the *Nucleus of Tseltal community wellbeing*, which is at the center of what the participants/collaborators call the four building elements of *buhts'an qu'inal* (Figure 2).

Figure 2. Nucleus of Tseltal community wellbeing.

The three interconnected components of *the Nucleus of Tseltal community wellbeing* are the Tseltal individual, the Tseltal family, and the Tseltal community. As illustrated in

Figure 2, these components are dependent on each other. The *Four Elements of buhts'an qu'inal* are *Scanantayel slecubel baqu'etalil* (our bodies' health), *Slehel slamalil qu'inal yu'un swinquilel lum* (harmony in our relations), *Sc'oblal scanantayel sjoylejal bahlumilal* (wellbeing of our land), and *Sna'el ya'beyel stuc te bin ay ma'yuc* (the harmony in the relationship between what we have and what we need). During the data analysis, the ST identified additional aspects that provide a better understanding of how these four elements are interconnected to each other.

Based on these findings, *Buhts'an qu'inal* can be translated into English as the physical and emotional state of savoring life in harmony with the surrounding community, which includes the natural environment. It is a temporary state of body and mind with deep communal components, and its meaning can be interpreted in multiple ways because the expression works as a metaphor, adapting to each Tseltal individual, family, and community's conception of how experiencing a "delicious" moment feels.

Each of the *Four Elements of buhts'an qu'inal* can be examined and explained from each of their components, meanings, and indicators, but this endeavor is beyond the purposes of this article. The results of the research show the multiple dimensions in which Tseltal knowledge and practices are grounding the work of Tseltal women entrepreneurs in the six participant communities. They offer deep immersion in Tseltal ontology and epistemology and show how the collaborators/participants of this research are leveraging their traditional practices and ways of understanding life to promote their communities' wellbeing.

Tseltal knowledge and practices are rich and complex; it would be impossible to observe, study, and interpret their depth and reach all their dimensions in one research study. For the purposes of this research, the collaborators/participants focused on studying the element of *Sna'el ya'beyel stuc te bin ay ma'yuc* (the harmony in the relationship between what we have and what we need) or the Tseltal understanding of community economic wellbeing. The collaborators/participants of this study identified that one way in which the results can be interpreted and discussed for academic purposes is by taking the main indicator of success for their entrepreneurial initiatives and systematizing it in the form of four aspects that were identified as critical in their endeavors.

The results show that the main indicator of success in the development of *sHachel jwohc' a'tel* (Tseltal initiatives of entrepreneurship) is the sustained engagement of the women Indigenous entrepreneurs in the collaborative work oriented to *Sna'el ya'beyel stuc te bin ay ma'yuc* (the harmony in the relationship between what we have and what we need) or community economic wellbeing. The elements of this sustained engagement were systematized into four aspects that were identified as critical in guiding and defining the collaborative efforts in developing *sHachel jwohc' a'tel* (Tseltal initiatives of entrepreneurship): 1. Consistency in the relationships, 2. Knowledge of the local culture and traditions, and experience in working in the local communities, 3. Fluency in the local ways of communication and language, and 4. Grounding the work in related local practices.

The discussion of these four aspects is oriented to offer a glance at the different ways in which Tseltal entrepreneurs, especially Tseltal women, are designing and leading innovative ways to promote the economic wellbeing of their communities through collaborative entrepreneurship initiatives while remaining deeply grounded in their traditional knowledge, roles, and practices. In this study, the results show that for Indigenous entrepreneurs, their traditional knowledges offer them a reliable framework that outlines effective protocols for capacity building, stakeholder engagement, and collaboration. Specifically, in the case of the participant Indigenous women entrepreneurs, their Tseltal knowledge and practices are sources of creativity and innovation that are constantly supporting them in overcoming challenges and opening up new pathways and opportunities for social change and community thriving.

4. Discussion

Social capital can be defined as "the aggregate of the actual or potential resources which are linked to possession of a durable network of more or less institutionalised relationships of mutual acquaintance or recognition" [29] (p. 248). In the case of social innovation, social capital works as networks of relationships among the local community that enable certain resources or processes to take place, often resulting in productive benefits [30] (p. 123). Social capital grounded in Indigenous entrepreneurs' sense of collectivity can potentially promote "continuous learning, innovation, and adaptation to market opportunities" [31]. The consistency in the relationship between IXIM AC and the Indigenous entrepreneurs of the participant communities was identified as a relevant factor that effectively promotes mutual trust. This mutual trust has enabled the capacity of the participant Tseltal communities to increase the social capital of their entrepreneurial initiatives by expanding their stakeholders' networks through those of IXIM AC. This is an interesting idea because social capital is a resource that grows the more it is shared by continuously generating prospects for building new strategic alliances [32]. The scholarship in this regard agrees that the creation of alliances in Indigenous contexts is a complex endeavor [33], but also that it is worth it because it does not only create opportunities for mutual learning and innovation, as argued by Peredo [30], but also has far-reaching impact in other levels such as "political influence, mobilization potential, and specific kinds of expertise" [34]. In addition, Indigenous entrepreneurs tend to use their enterprises as a means to achieve different kinds of purposes other than just those at the economic level, including the holistic wellbeing of their communities and self-determination and assertion over their territories [2,35,36]. Based on these ideas, it can be argued that using and promoting social capital can be a key strategy for Indigenous entrepreneurs and their organizations in reaching impact at different levels to achieve their goals and diverse purposes.

The study findings suggest that the meaning of harmony in Tseltal culture is directly linked to an idea of communal balance that is supported by equality in everything related to the *Nucleus of Tseltal community wellbeing* and through the *Four Elements of buhts'an qu'inal*. The participants/collaborators in this study identified that having experience in practicing this communal balance in the participant Tseltal communities was the ground of IXIM AC's rationale for focusing on specifically promoting the participation of Tseltal women entrepreneurs in initiatives of community economic development. The component of the Tseltal ideas of balance supported by equality is the window that enabled the participant Tseltal women entrepreneurs the opportunity of addressing their communities' needs. By leveraging their traditional roles at the three levels of the *Nucleus of Tseltal community wellbeing* (individual–family–community), they reach new areas of action that, based on the findings of this study, are transforming the ways in which they perceive themselves. The findings of this study include evidence that the participant Tseltal women entrepreneurs are boosting their self-confidence and sense of empowerment, while feeling rooted in their traditional practices and local traditions.

Indigenous women entrepreneurs (IWE) are underrepresented in the entrepreneurship scholarship despite the fact that Indigenous women's work is recognized as crucial in promoting community wellbeing [37] while also having lower economic status and with women entrepreneurs more frequently having to confront and overcome acts of discrimination from the dominant society, especially in Indigenous communities that have primarily male-dominated cultures [38]. The findings of this study show that the active participation of women in entrepreneurial activities is effectively transforming their situation of vulnerability by promoting their self-confidence and empowerment through the development and success of their economic enterprises. However, there is an additional element that is crucial as a gender transformative activator in the unique approach of the participants/collaborators of this study: the space for self-reflection and analysis about their own endeavors. The results of this study suggest two ideas about gender transformative approaches. First, as Croce [38] and Castañeda Salgado [39] suggest, integrating

intersectionality and positionality in undertaking research about Indigenous women in entrepreneurial ventures contributes to a better understanding of the unique perspectives and experiences of Indigenous women in entrepreneurship. Second, gender transformative impact in Indigenous communities cannot be achieved solely by promoting initiatives that promote Indigenous women's self-confidence and empowerment, such as activities related to Indigenous entrepreneurship. These initiatives must also be guided and accompanied by practices that are aligned with the local traditions and women's Indigenous knowledges. This second idea has at least two implications: 1. Organizations that aim to undertake gender transformative approaches to promote entrepreneurial initiatives in Indigenous communities need to have enough experience working with them in mutual-trust embedded relationships to understand the local traditional knowledges and practices; and 2. Working as a collaborator with IWE in promoting their enterprises requires one to make space for intersectionality and positionality, or in other words, self-introspection and analysis of the intersections and interdependence of the Indigenous women's position and roles in their communities and with current and potential stakeholders. Furthermore, this needs to be undertaken in a way that is aligned with their traditional knowledges, practices, and languages.

IXIM AC's initiative of avoiding direct translations and developing Tseltal concepts from Tseltal understanding to collectively reflect with the participant communities about specialized knowledge related to their entrepreneurial ideas emerged from this organization's experience in participatory methods. Since the 1950s, participatory action approaches in Latin America have generated several experiences of participatory communication that seeks to address the needs of the most vulnerable in this region to generate social transformation [40]. Magallanes Blanco explains that the concept of Communication for Social Change emerged from these experiences and it has been defined as a process of dialogue and debate, based on tolerance, respect, equity, social justice, and the active participation of all, in which the communication process is more important than the results. The results of this kind of communication are only manifestations of the participation and reflection of the members of a community, but the critical aspect is that the reflection process is owned and undertaken by the members of the community to address their specific needs while promoting respectful dialogue [40] (p. 44). This study's results suggest that the participatory approach and the collective reflection that are part of the process of Communication for Social Change can be significant generators of locally grounded strategies that can serve Indigenous communities' communication needs related to undertaking and developing initiatives of Indigenous entrepreneurship.

A common characteristic across Indigenous communities is their ability to overcome adversities despite the fact that most of them live in imposed situations of vulnerability [1,41]. For the last five hundred years, Indigenous communities have been facing and resisting the consequences of colonialism: from direct violent attacks to erase them and their cultures, through the plundering extraction of the natural resources of their traditional territories, to being forced to participate in paternalist programs that even today continue threatening their traditional ways of living and capacities for self-sufficiency and self-determination [27,42,43]. Indigenous peoples' capacity for resilience has been noted across multiple disciplines, and Indigenous entrepreneurship is not the exception. Diverse studies show that Indigenous entrepreneurs believe that their traditional knowledges and practices are strong, adventurous, and robust enough to enable paths to economic self-determination [44].

Many of the consequences of the 2020–2021 Covid-19 pandemic have been devastating for many economies around the world, especially in regions where people were already in vulnerable economic situations, such as in Indigenous communities [45–47]. However, the results of this research show that the challenges that emerged from the pandemic generated innovative ideas from the groups of Tseltal women entrepreneurs in each community, and there was renewed enthusiasm in leveraging the existing information technologies available in the region and even embracing the alternative of learning to use new ones.

Resilience encompasses a series of capacities and abilities, which are acquired as a result of the interaction of individuals with their contexts. By being exposed to adverse events in these contexts, individuals are able to overcome their own limits of resistance through the generation of increasingly more efficient defense and protection processes and mechanisms. Some studies suggest that the six key elements in the process of developing resilience in Indigenous women in Mexico are social competence, family support, personal structure, strength and self-confidence, social support, and internal locus of control [48]. These six key elements were identified in the strategies undertaken by the collaborators/participants of this research in facing the challenges of the Covid-19 pandemic. However, in the case of this research study, there is an important factor that was crucial in the development of strategies: the work of the *jTijaw*.

The *jTijaw* were the ones who established the bonds of communication and trust among the Tseltal women of their groups and the members of IXIM AC. By leading the activities in their communities and proactively including new responsibilities in their roles, they minimized the transit of external actors across the participant communities. They followed up with the projects of the family gardens and the use of the installed ecotechnologies in their communities, and they also monitored and evaluated each of the activities of the distance training program. It was due to their continued work and motivation, grounded in their traditional knowledges and practices, that the project gained resilience and opened up new opportunities for expansion and innovation. The results showed that the *jTijaw*'s approach is grounded in their traditional roles. The critical aspect of grounding the work in related local practices speaks specifically of leveraging these practices, guided and led by local Indigenous elders and leaders, to provide the necessary strategies to face emergent challenges.

In studying Indigenous resilience, it is important to keep a skeptical perspective on the mainstream programs in the topic, since they are usually grounded in psychological and neoliberal agendas which usually focus on isolating the characteristics of resilience in the individual. Indigenous resilience is diverse; it can take many forms and be practiced in multiple ways distinctive of each Indigenous culture. Yet, studies show a common characteristic in the distinctive Indigenous processes of developing resilience: "in all cases, resilience was shifted from the individual to the collective, which aligns with an ecological, systems model that involves nesting layers of individual, family and community within a cultural and political context" [49] (p. 119). Resilience grounded in collectivity surpasses the dimensions of individual resilience, reaching a level that relates more to the cultural dimension. Cultural resilience is "the capacity of a distinct community or cultural system to absorb disturbance and reorganize while undergoing change so as to retain key elements of structure and identity that preserve its distinctness" [50] (p. 120). The results of this study suggest that the *Nucleus of Tseltal wellbeing*, grounded in the individual–family–community symbiotic dynamics across the *Four Elements of Buhts'an qu'inal*, is the framework in which the collaborators/participants' strategic knowledge to solve problems is developed and accumulated. This strategic knowledge is communal and intrinsic to the Tseltal culture, which positions the capacities and work of the *jTijaw* and their groups at the level of cultural resilience, beyond simple individual adaptation.

5. Conclusions

Indigenous knowledges and ways of seeing life invite us to look at the aspects and models of development using the lenses of local communities, understanding their wise practices for community wellbeing. By integrating these perspectives, we have an opportunity to design new narratives for development that can allow us as a society to be in active partnership with nature. This partnership can in turn reposition Indigenous communities as active participants in nurturing life while fostering their distinctive knowledges that inform and guide local values and means of production, exchange, communication, and enjoyment. In this scenario, concepts such as *sustainability, growth,* and *development* become

almost redundant, opening up the possibility of exploring local understandings of the conceptual frameworks of *community wellbeing*.

Another important dimension of this study's contribution implies a call to the academics in the field of Indigenous entrepreneurship for collective action to position Indigenous communities' needs, knowledges, and distinctive ways of understanding community wellbeing as the fundamental rationale for undertaking research (or at least at the same level as their personal or organizational interests). This implies a continued effort to keep in mind that in many cases the studies related to Indigenous entrepreneurship must start from unlearning the mainstream approaches to studying entrepreneurship, which are usually aligned to Western perspectives, and are oriented to "make room" for alternatives within capitalist structures. In the field of Indigenous entrepreneurship, researchers must be prepared to explore practices in which the economic purpose of the enterprises serves only as a means to weave a fabric consisting of intertwined social, cultural, spiritual, and environmental strands; and enterprises in which the generation of wealth or financial efficiency are not adequate indicators to define success for Indigenous entrepreneurs; and cases in which the ultimate goal is as simple—and complex—as achieving a communal enjoyment of life.

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Institutional Review Board Statement: The study was conducted according to the guidelines of the latest edition of the Canadian Tri-Council Policy Statement (TCPS): Ethical Conduct for Research Involving Humans. It was approved by the Trent University Research Ethics Committee, the Trent University Ph.D. in Indigenous Studies Research Ethics Committee, and the Trent Aboriginal Education Council in January 2020. These committees follow the Tri-Council Policy Statement 2 (TCPS2 2018 version) ethical research framework. Specifically, this research follows the Tri-Council's Chapter 9 methodological and ethical framework on research with Indigenous peoples, as well as the Ethical Guidelines for Research Best Practices outlined by the Royal Commission on Aboriginal Peoples, and other emerging codes in Indigenous research.

Informed Consent Statement: Informed consent was obtained from all subjects involved in the study and written informed consent has been obtained from the participants to publish this paper.

Data Availability Statement: The data that support the findings of this study are available on request from the corresponding author. The data are not publicly available due to alignment with the agreements made for this research in January 2020 with the participant communities, the Trent University Ph.D. in Indigenous Studies Research Ethics Committee, and the Trent Aboriginal Education Council. These committees follow the Tri-Council Policy Statement 2 (TCPS2 2018 version) ethical research framework. Specifically, this research follows the Tri-Council's Chapter 9 methodological and ethical framework on research with Indigenous peoples, as well as the Ethical Guidelines for Research Best Practices outlined by the Royal Commission on Aboriginal Peoples, and other emerging codes in Indigenous research.

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Proceeding Paper

Environmental Justice and Green Spaces in Ibadan Metropolis, Nigeria: Implications on Sustainable Development in Urban Construction †

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Abstract: Environmental justice (EJ) in urban construction is lacking, and it is a major concern towards achiving some of the sustainable development goals (SDGs). It is the fair treatment and meaningful involvement of all people regardless of race, sex, national origin, or income with respect to the development, implementation and enforcement of environmental laws and policies. This study employs the concept of EJ in explaining the fairness in the distribution of green spaces (GS) with regard to urban construction in Ibadan metropolis, Nigeria. The study revealed that GS distribution is more a function of the pattern of unplanned and uncontrolled physical developments than of a deliberate effort by the people or government to maintain the GS.

Keywords: urban construction; green spaces; environmental justice; GIS; sustainable development

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1. Introduction

Construction and real estate have been central to the debates on sustainable development. The improvement of the green space system can reduce the negative impact of urban construction on natural ecosystems, and improve the living standard of urban residents. Urban green areas therefore consist of open spaces, generally covered with natural or planted vegetation [1]. Urban green spaces (UGS) can be of many shapes, forms, functions, and purposes. They can vary from a simple playing field to a natural landscape or highly maintained environment to which the public are mostly granted open access, although some may be privately owned. The most famous UGS are the amenity green spaces, having a high quality of landscape design and maintenance. Urbanization has enormous impact on green spaces, and it is not surprising that studies of different aspects of urban green spaces are gaining momentum among urban researchers [2]. In Africa, the situation is worse. Studies in several African countries revealed that there is intense pressure on green spaces for different human activities especially urban construction resulting in persistent deterioration of these spaces [3]. At the moment, the rapid depletion of green spaces in Africa has resulted in green spaces occupying a very small proportion of the total land space of many urban areas. For example, several towns in the Republic of South Africa have less than 10 percent of their total lands occupied by green spaces [4].

Furthermore, studies have considered the role of social ecology of a city in explaining the processes that lead to greening or de-greening bearing in mind that human beings play a major role in shaping the natural environment. However, only a few studies have addressed the impact of green space distribution on human groups in relation to the concept of environmental justice (i.e., the fair distribution of environmental burdens and benefits) since green spaces are not supposed to be restricted to one part of a geographical space [5,6]. The pertinent question is who then are the disadvantaged population in terms of green

space distribution in urban construction? These are among the issues that this research seeks to address.

The conceptual contribution of environmental justice in green spaces studies have been addressed by different authors and have been summarized in Table 1 below.

Table 1. Summary of Conceptual Contribution of Environmental Justice.

Conceptual Contribution of Environmental Justice	Variables to Measure	References
■ Distribution of human groups varies across a geographical space. ■ The distribution pattern of human groups influence the distribution of environmental burdens and benefits. ■ The differentiation in human groups will bring about hierarchical domination which will lead to a section of human groups becoming disadvantaged.	Socio-economic Characteristics	[7–12]

Complied by author 2021.

The aim of this study therefore is to investigate the major socioeconomic characteristics of the communities in Ibadan metropolis that explain the disparities in the spatial distribution of green spaces in the context of environmental justice and assess the implications on sustainable development in urban construction. The major research questions of the study are:

i. Who are the disadvantaged population?
ii. What is the role of the government in ensuring environmental justice of green spaces?
iii. How does the existing distribution affect sustainable development in urban construction?

2. Methods and Materials

2.1. Research Design and Sampling Technique

Ibadan metropolis is located in south-western Nigeria, 128 km inland northeast of Lagos and 530 km southwest of Abuja, the federal capital and lies between longitude 3°54′ East of the Greenwich meridian and 7°32′ North of the equator. This study involved measuring and mapping of green space distribution. A high-resolution satellite image (SPOT) of Ibadan for the year 2015 was purchased from glovis.com to extract and measure the green spaces. The distribution of the various human groups (socio economic characteristics) within the study area was also mapped. The community map of Ibadan metropolis (Figure 1) was used as base map and data and information were collected on the basis of the 104 communities or communal areas identified in the metropolis.

2.2. Indicators for Assessing Environmental Justice (EJ)

Indicators for assessing environmental justice were derived from data and information collected through the administration of structured questionnaire and Focus Group Discussion (FGD) based on the community map of Ibadan metropolis. Section A of the structured questionnaire addressed the ten individual variables. The individual variables were selected based on what is applicable and available in the Nigeria context. The ten indicators included gender, age, education, occupation, income, ethnicity, religion, housing type, housing structure; wall materials and roofing materials. Each indicator consists of more than two variables $\times 1$, $\times 2$, $\times 3 \ldots$). On the other hand, section B and C of the structured questionnaire addressed the perceived component and were analysed using descriptive method of explanation (percentages). Copies of the questionnaire were distributed by adopting a stratified random sampling technique in which Ibadan metropolis was divided based on population density using four sample percentages (0.1%, 0.2%, 0.4% and 0.8%). The total projected population for 2015 was estimated at 1,783,367 and the total number of people to be surveyed was estimated at 3410 that were selected at regular intervals. Twenty—one groups emerged for the FGD by considering the proximity/distance of

localities from one another. The target audience was the elders who had information about the oral history of their communities.

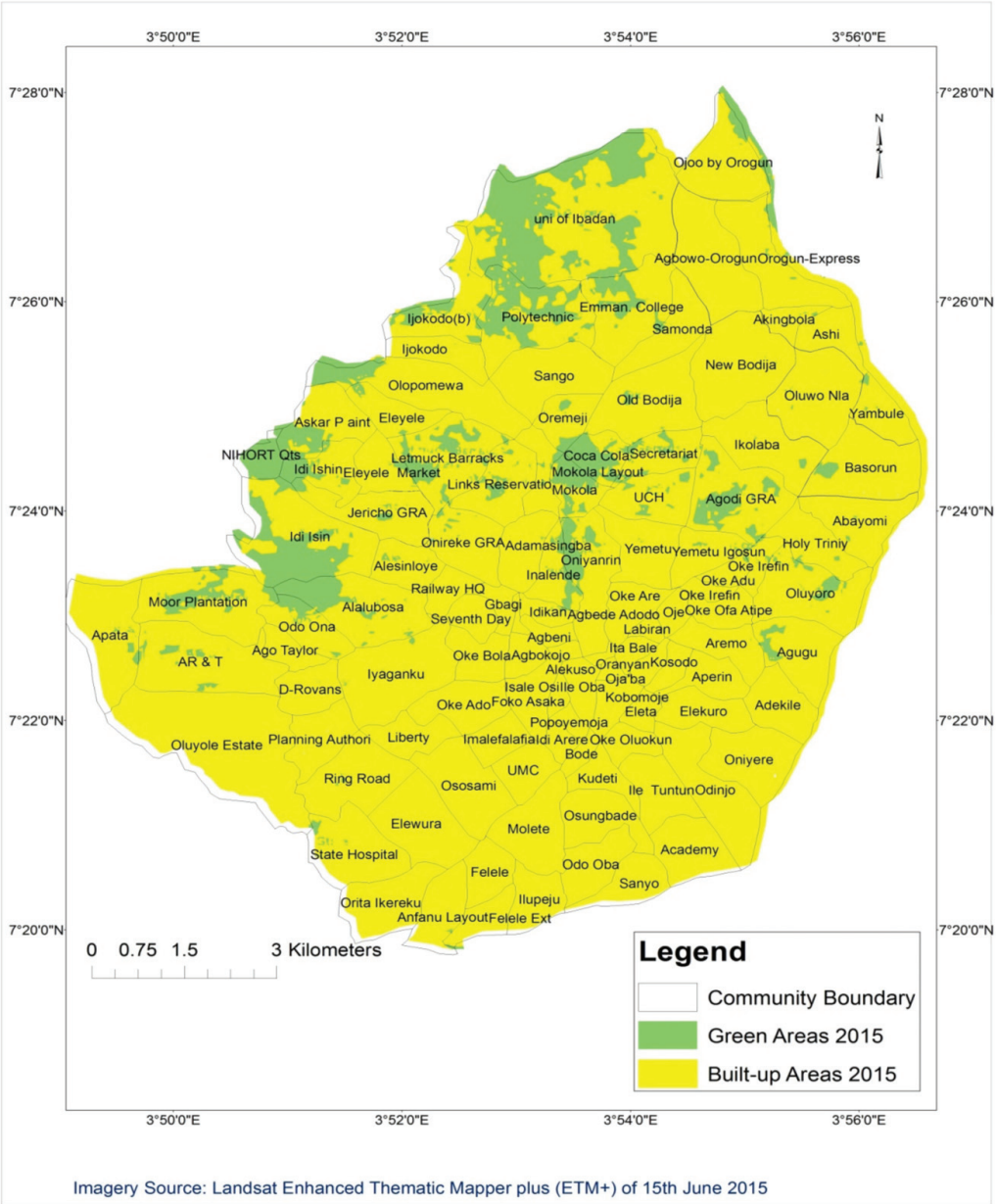


Figure 1. Green space distribution showing disadvantaged communities Ibadan Metropolis.

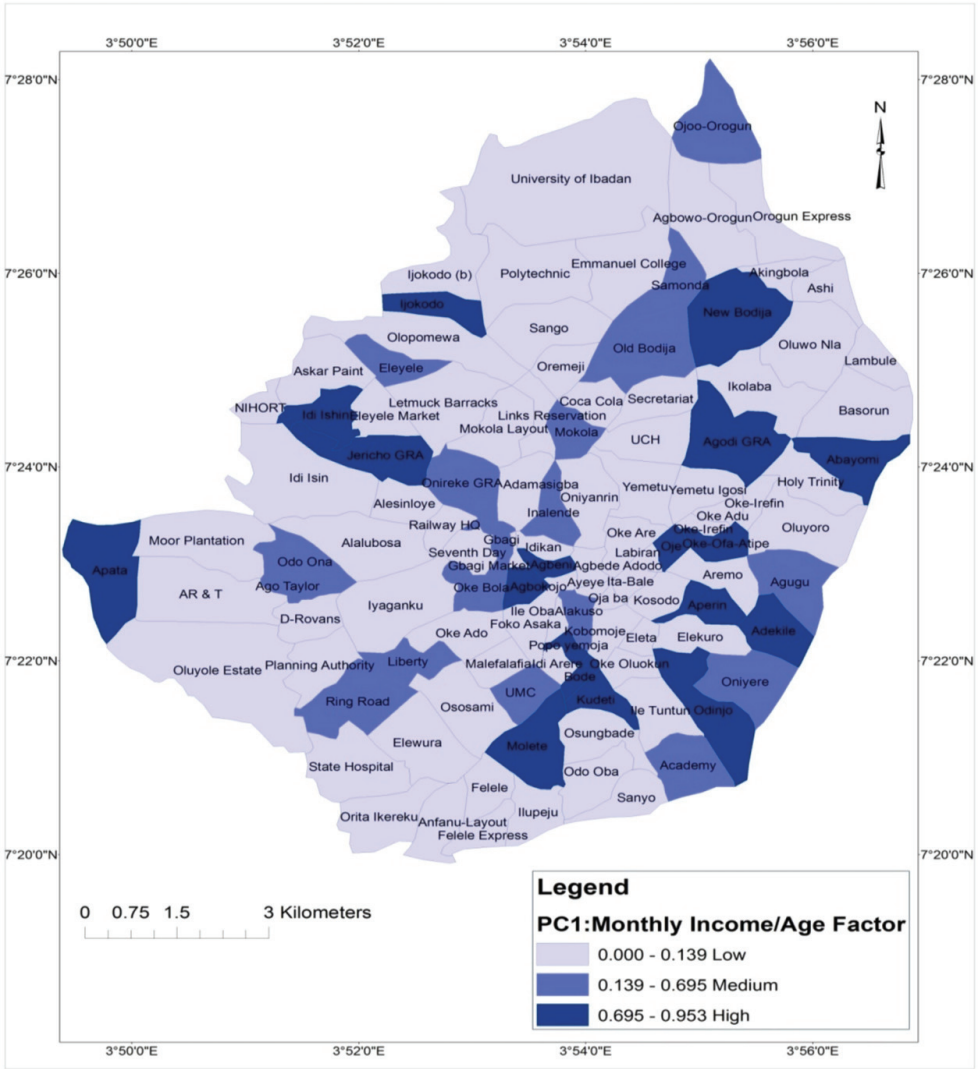
2.3. Analytical Tools for Assessing Environmental Justice

Three main methods of analysis were applied to achieve this goal, namely, (i) principal component analysis (PCA), component scores (the new given principal components/factors) were mapped to show the spatial variations of human dimenssion in the context of environmental justice of green spaces, and (ii) ordinary least square were used to identify the significant indicators; (iii) the geographically weighted regression analysis package of ArcGIS software was used to visually identify the socio-economic indicators of the environmental justice of green space. The input variables for the GWR therefore included "green space in sqm^2 for 2015, and the socio- economic parameters".

3. Results

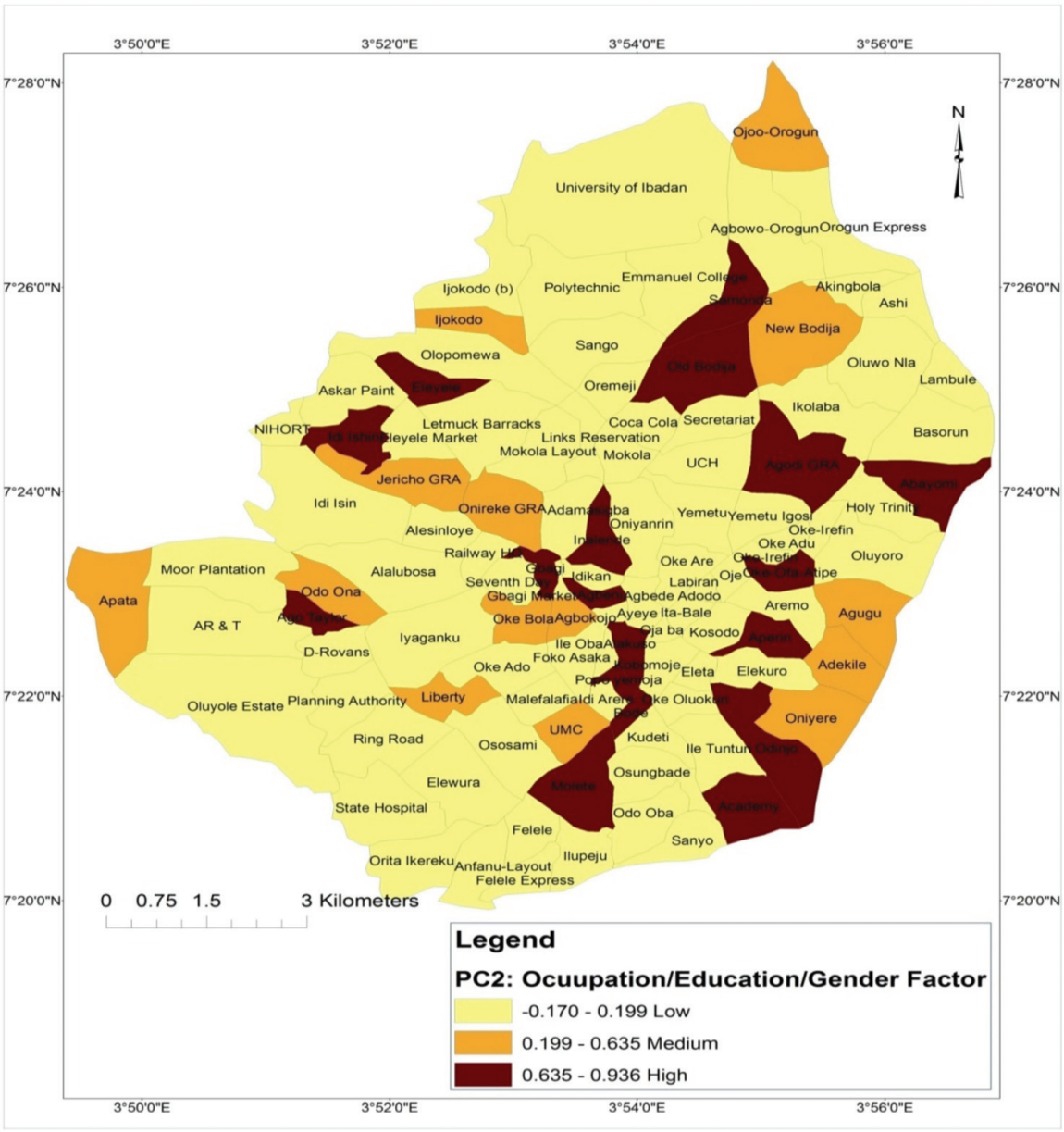
3.1. Pattern of Green Spaces in 2015 (Indicating the Extent of Disadvantaged Communities)

Figure 2 shows that green spaces remained sparsely distributed for 2015, whereas areas with large volumes of green spaces were still linked with government reserved areas (GRA). However, significantly, some new areas emerged with small pockets of green space that were not there before. From the FGD conducted in these communities, it is clear that the metropolis is now congested, and green spaces are found in fenced areas, in compounds and in the interior parts of the communities which are not suitable for construction. From the green space measurement carried out the majority of the communities now have green spaces within the range 10,000 m^2 to 100,000 m^2 (1–10 ha). In other words, small sized green spaces now predominate in the metropolis. However, some communities are more at disadvantaged than others as shown in Figure 2. The variation palette in Figure 2a–e shows that the dark colour communities represent areas that are most at disadvantaged compared to the relatively light colour communities. Interestingly, the main factor responsible was urbanization characterized by the construction of residential, commercial and industrial buildings, roads and other social infrastructures.



(**a**)

Figure 2. *Cont.*



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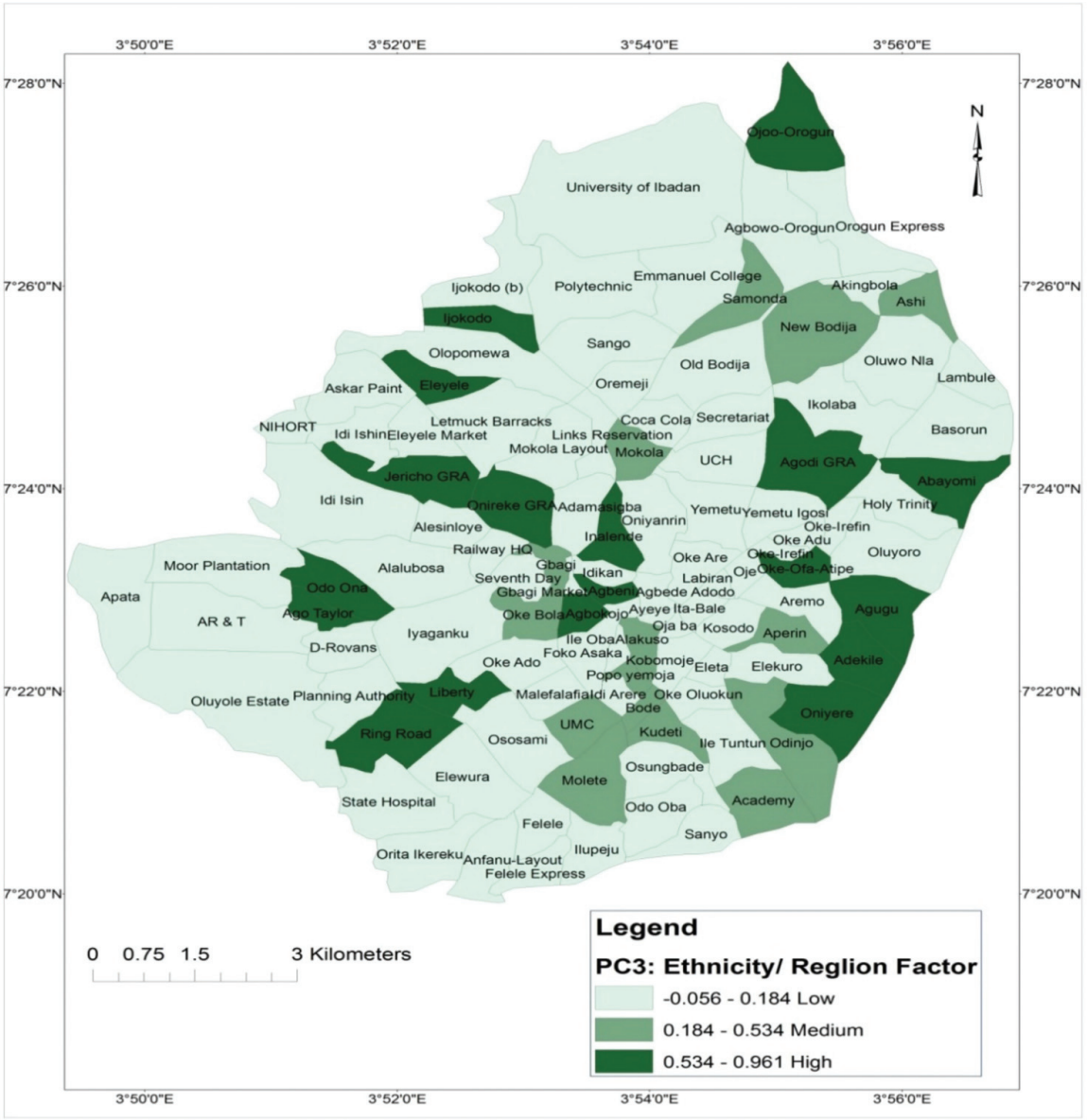

(**c**)

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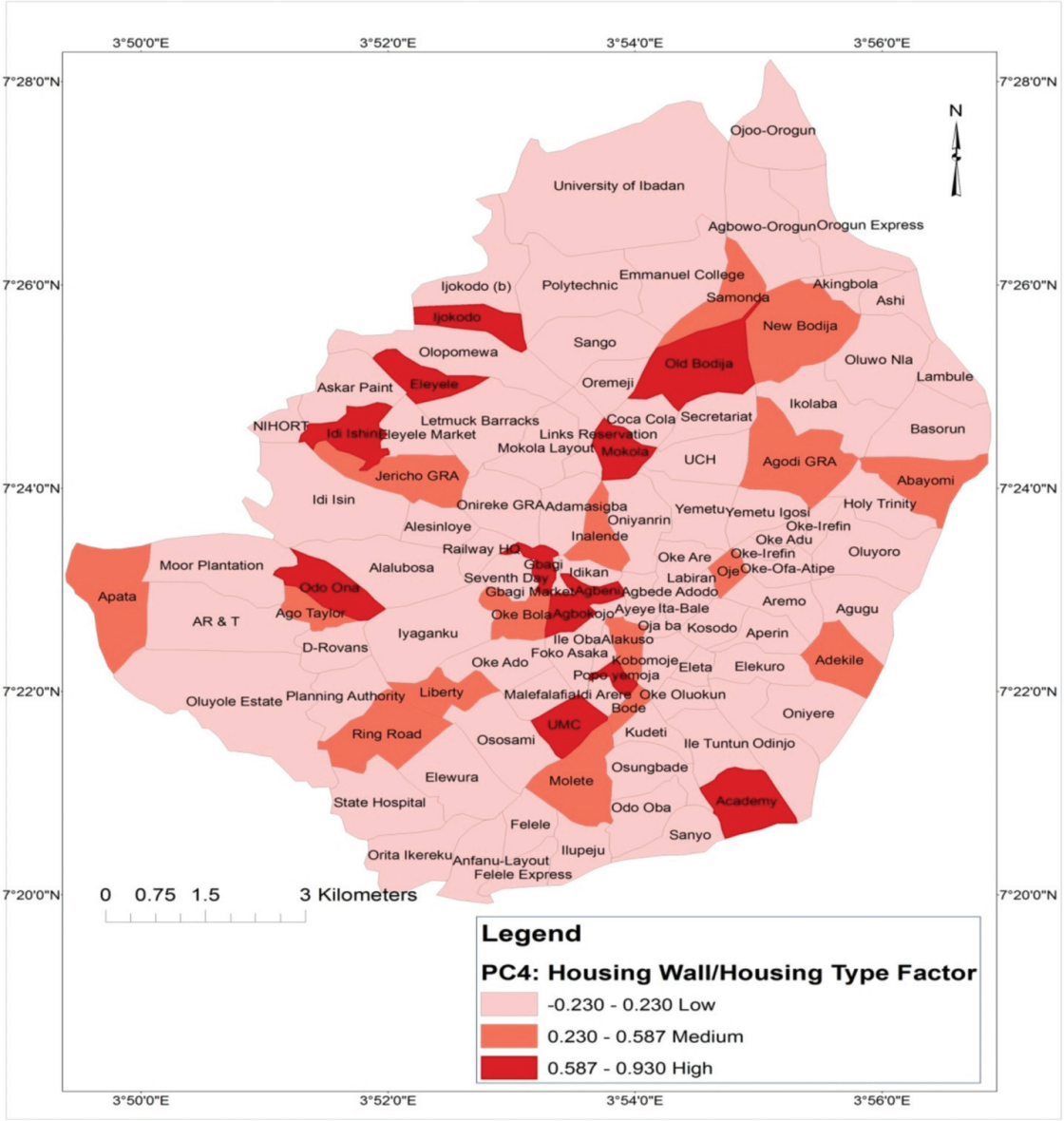
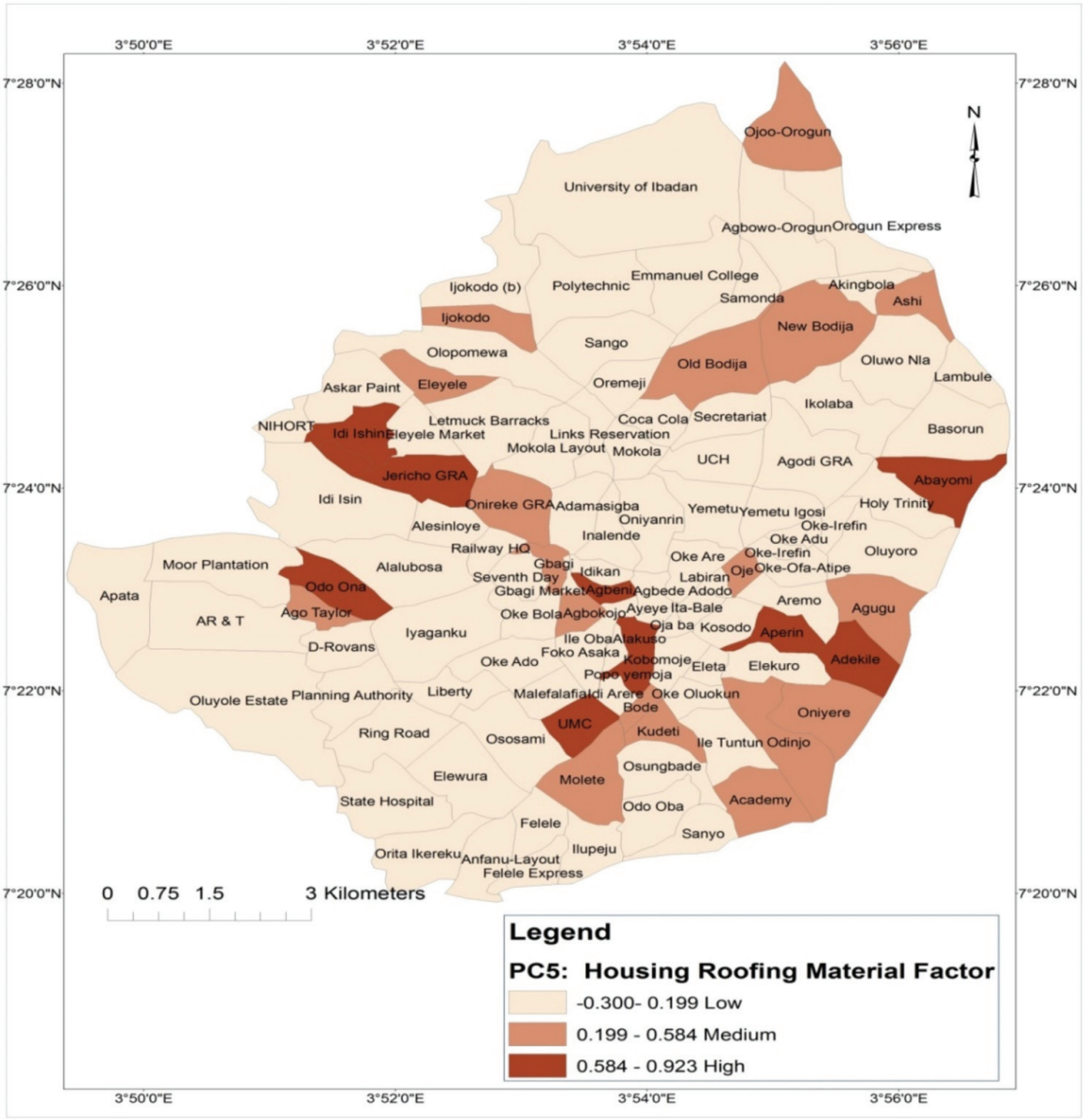


(d)

Figure 2. *Cont.*



(**e**)

Figure 2. The existing concentration of the various human groups in Ibadan Metropolis based on five dimensions (**a**) Income/Age factor; (**b**) Occupation/Education/Gender factor; (**c**) Ethnicity/religion factor; (**d**) Housing wall/Housing Type factors; (**e**) Housing roofing material Factor.

3.2. Environmental Justice Assessment

3.2.1. Principal Component Analysis

Principal component analysis (PCA) was employed to identify the underlying human group dimensions in the data sets which were collapsed to fewer uncorrelated components. The factors with the highest loadings of PC1 are monthly income (0.647) and age (0.595), whereas the highest PC2 loadings are by occupation (0.542), highest level of education (0.419) and gender (0.153). Ethnicity (0.452) and religion (0.413) load highly on the PC 3; housing wall materials (0.333) and housing types (0.331) load highly on PC4, whereas the highest loading of PC5 is by housing roofing material (0.267). Given the nature of the component loadings, the first PC was referred to as income/age; the second as oc-

cupation/education/gender; the third as ethnicity/religion; the fourth as housing wall material/housing type; and the fifth as housing roofing material.

3.2.2. Ordinary Least Square and Geographically Weighted Regression (GWR)

The next stage was to perform an Ordinary Least Square regression and a Geographically Weighted Regression in order to identify which of the factors assisted in assessing the how environmentally just is the distribution of green spaces in the metropolis. The summary of the OLS using ARCGIS 10.4.1 (Statistically significant *p*-value ($p < 0.01$) are: Income 0.004*; Occupation 0.010*; Housing type 0.001*.

The input variables for the GWR OF ArcgIS 10.4.1 therefore included "green space in sqm^2 for 2015; Income; Occupation; and Housing type. The output results are as follows: Bandwidth: 0.02; Residual Squares:1672717481970.27; Effective Number: 44.36; Sigma: 157262.17; AICc: 3043.3; R2: 0.39; R2Adjusted: 0.52. Dependent Variables: Green Spaces_2015sqm; *Explanatory variables*: Income, Occupation and housing type.

3.2.3. Geographically Weighted Regression (GWR)

Figure 3 therefore identifies the communities where the significant EJ indicators (income, occupatiom, housing types) have the greatest influence in explaining the uneven distribution of green spaces (combined: Local R^2). From the map, examples of communities that exhibited very strong effects of the interplay of social indicators in explaining green space variation include Sanyo, Odo Oba, Ijokodo, Apata, Oluyole Estate, etc.The core or central parts of the metropolis exhibit only moderate impact on green space distributional pattern. They include communities such as Felele, Agugu, Oluyoro, Idi shin, Aremo, etc.

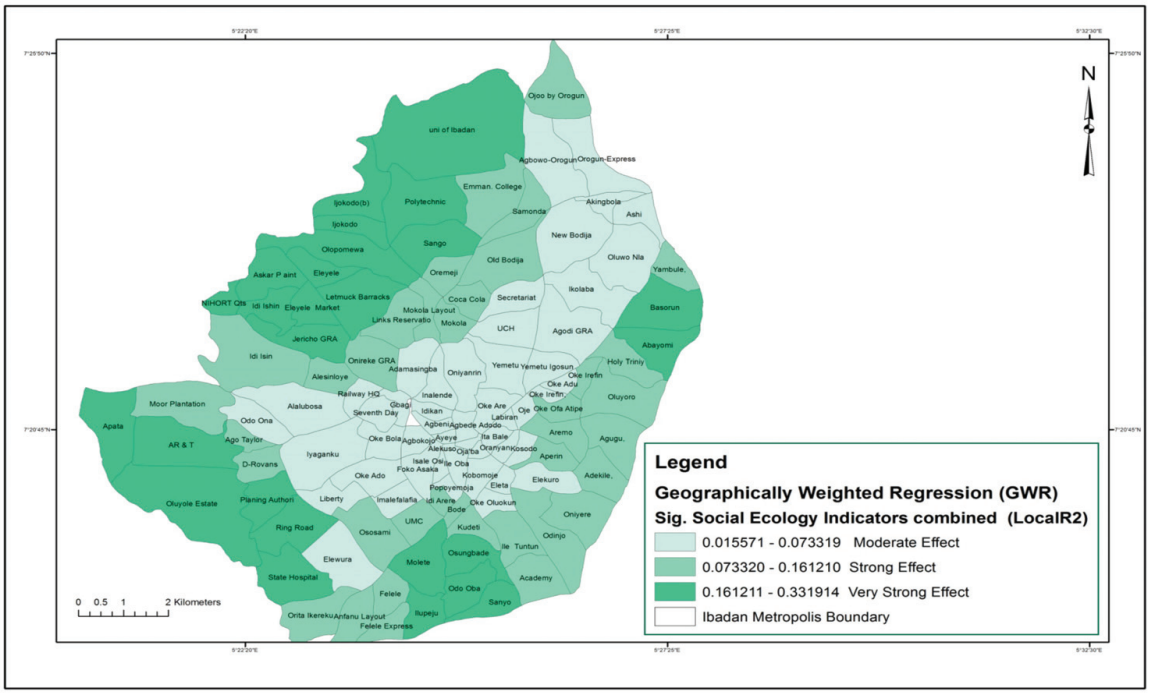


Figure 3. Variation level of disadvantaged Communities based on EJ indicators combined.

3.3. Perception on Green Spaces and Environmental Justice in Ibadan Metropolis

Result of the analysis show that 49.8% have trees as the major type of green spaces in their neighborhood. This was followed by compound grasses 46.0% and gardens/lawn 46.3%, respectively. Remarkably, roadside grasses were relatively high across the three residential zones (Low: 27.2%; Medium: 38.9%; High: 33.9%). Grass field was quite low in the low residential density zone. 50.3% have no green spaces in the medium density

areas, whereas 33.2% have no green spaces in the high-density residential areas. The low density residential had the lowest percentage (16.5%) of respondents with no green spaces. The implication of this is that de- greening activities are quite high in Ibadan, and it is concentrated in the medium residential density areas. The various green space types are evident across the residential zones. However, notably are the roadside grasses, compound grasses and grass field (see Figure 4), which suggests a natural course rather than a deliberate attempt to preserve the green spaces.

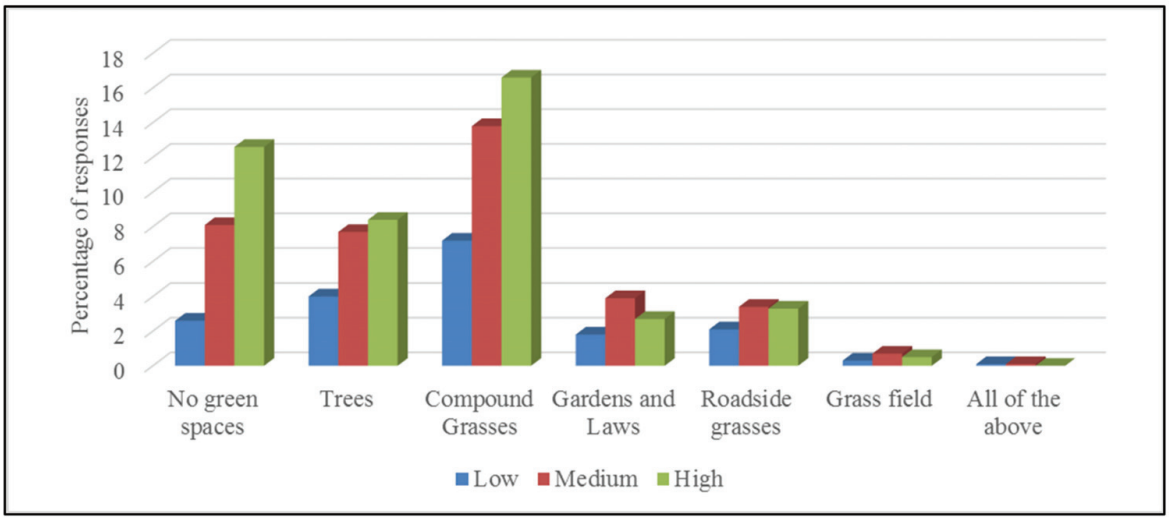


Figure 4. Types of green spaces by residential density.

3.4. Implications of Environmental Justice of Green Spaces on Sustainable Development in Urban Construction

The question at the Centre of environmental justice (EJ)) debate is whether there is an association between people's socio-economic position and their exposure to environmental burdens as green space depletion. Additionally, how existing attitudes of individuals can help better explain their attitudes toward certain environmental behaviors as regard urban construction. Results and findings from this research study shows that environmental justice is lacking in Ibadan Metropolis and the urban construction is below satisfactory based on the following observations:

(1) There is no fair or even distribution of green spaces in Ibadan Metropolis: Findings from this research project show that green spaces were clustered in some communities and communities which had no green spaces were also clustered. The theoretical explanation therefore from the environmental perspective shows that the attitude of Ibadan residents towards greening varies. While some have a positive attitude, others have negative attitudes, hence the uneven distribution of green spaces.

(2) Government involvement of the people in the greening process is absence: Results and findings from the perception survey and Focus Group Discussion indicate that the government has accomplished little in ensuring the maintenance of green spaces and guiding against indiscriminately cutting of trees, etc. Reports from the FGD show that decisions on the environment are totally left in the hands of the people though their Landlord Association and community heads.

(3) Laws, Policies and regulations on urban construction and development are not adhere to by government officials: Governmental officials such as the town planning authorities, Ministry of Lands, Housing and Development, Waste Management Authority and the Agency of Urban Beautification have not been carrying out their duties effectively. This is evident by the allocation of land for construction without proper layout spacing and consideration for green.

4. Conclusions and Recommendation for Sustainable Development

The 2030 Agenda and its Sustainable Development Goals (SDGs) offer new opportunities for the building sector to expand its focus. Studies in several African countries revealed that there is intense pressure on green spaces from urban construction resulting in persistent deterioration of green spaces. This has resulted in green spaces occupying a very small proportion of the total land space of many urban areas emanating into a process called degreening. Therefore, this study is based on the premise that economic growth (building sector) can and should occur without damaging the social fabric of the community and without harming the environment. The recommendation given for this research project is based on the findings and observations of the study. The major recommendations as follow are:

- Restructuring of Ibadan Metropolis through Urban Revitalization and Environmental Planning: Revitalizing and restructuring the Ibadan metropolis will not go without a cost in terms of demolition of houses to accommodate green landscape, displacement of people and compensation plans by the government. A systematic approach of proper urban planning and environmental planning is required bearing in mind the concepts of environmental justice.
- Using Religion Platforms in Promoting Greening Culture in Ibadan Metropolis: Findings and observation from the research project show that one way to promote a healthy social structure and strong environmental Justice system across communities in Ibadan Metropolis is through the various religions we have (Christianity, Islam and tradition, etc.). There is strong respect for religion, and most religions have respect for the environment. Therefore, religious platforms can be used to bring about awareness on the importance of green spaces.
- Awareness of the climatic implications of greening through social media: The government show be more aggressive on educating its citizens on the importance of green spaces. Effective publicity can be achieved through social media: tv, newspaper, etc.
- Policies geared towards greening culture by house owners: Behavioral attitude cannot be easily changed. Therefore, bearing this in mind the government should take more drastic measures such as passing into law for the greening of compounds by house owners. Defectors will then be persecuted or fined. This conscious movement will restore the quality of the environment.

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Data Availability Statement: Data will be available on request.

Conflicts of Interest: There is no conflict of interest for this study.

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Youth Non-Profit and For-Profit Solutions toward Achieving Sustainable Development Goals in Russia: Practices, Challenges and Trends †

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Abstract: This research discusses the results of the Russian Youth Solutions Report 2021 that demonstrates Russian youth-led non-profit and pro-profit solutions working within the SDGs arena. It aims to investigate the challenges, practices, and trends of youth-led initiatives toward tackling critical issues under the SDG umbrella in Russia. Solutions included in the Report are based on the following criteria: youth-led/youth-focused solution, alignment with the Sustainable Development Goals (SDGs), and publicly expressed commitment toward achieving SDGs in Russia.

Keywords: sustainable development; SDGs; youth-led solutions; youth entrepreneurship; youth NGOs; Russia

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1. Introduction

In the remainder of 2020–2030, or the so-called "Decade of Action", young people will be an essential driving force behind the implementation of the Sustainable Development Goals. It appears that there are more and more youth movements in universities and schools and youth sustainable entrepreneurial and non-profit initiatives contributing locally to the achievement of the SDGs [1] (p. 15). In Russia, such youth for-profit and non-profit solutions are especially important to investigate for two main reasons. First, because of the lack of state-wide support of young initiatives towards SDGs, local small and medium-sized enterprises are more likely to contribute to the SDGs at local and regional levels in Russia. Secondly, the SDGs have received much attention in the last several years. However, despite this interest, no-one, as far as we know, has studied youth initiatives regarding SDGs before. The Russian Youth Solutions Report 2021 (herein, the Report) is the first attempt to collect and examine youth SDG-oriented initiatives, common practices, challenges, and trends in relation to Russia. The Report seeks to present a comprehensive analysis of Russian non-profit and pro-profit solutions working within the SDGs arena. Additionally, the Report provides an analytical assessment of the solutions and calls for attention to youth initiatives in the SDGs arena in an effort to gain support from stakeholders and promote sustainable development among young people in Russia. This paper introduces the main results of the Report and discusses the practices, challenges, and trends that youth solutions in Russia encounter.

2. Materials and Methods

This paper discusses the results of the Russian Youth Solutions Report 2021. To compile the Russian report, the SDSN Youth Russia team used the methodology for selecting and

classifying youth solutions from the Youth Solutions Report 2020. The Russian report's originality consists in applying an international methodology for collecting, classifying and analyzing youth initiatives and implementing the methodology in the Russian context.

In the first SDSN report, "youth solutions" were defined as "transformative projects and endeavours, ranging from entrepreneurial ventures to educational programs, including research activities, charity initiatives and others" [1] (p. 15). The report showed the innovative approaches that youth are taking in solving the multiple challenges of sustainable development. Accordingly, this definition was taken as the basis for the Russian report.

Youth solutions were collected simultaneously through a non-automatic search using the "snowball" method and an open call initiated by SDSN Youth Russia media channels, accessible for four months from March 2021 to June 2021. As a result, we received details of 70 youth initiatives. Overall, after review, 37 youth solutions were included in the Report, 16 (43.2%) of which were identified as "non-profit", while 21 (56.8%) turned out to be "for-profit".

Afterwards, the collected solutions were selected following the methodology of the SDSN Youth Solutions Program. The first stage was the exclusion of all solutions that fitted at least one veto factor: not youth-led/youth-focused, no SDGs focus, activity for at least three months, and expression of radical views (political, religious, others). According to the first stage results, 28 organizations that did not pass the veto factors were excluded. The second stage in selecting solutions was their more detailed study and analysis by SDSN Youth Russia volunteers. The SDSN Youth experts paid particular attention to commercial organizations to exclude the possibility of greenwashing and self-promotion at the expense of the Report. As a result of the second stage of the selection, six more organizations were removed from the list, of which four were commercial, and two were social movements that had not engaged in the activity for at least three months and did not meet the SDGs focus criteria.

The next stage of the Report was the analysis and description of the selected Russian youth solutions. The main criteria for the Youth Solutions Report 2020 analysis included location, model of operation (for/non-profit), youth-led or youth-focused, SDGs addressed, gender, and budget. The international analysis criteria were supplemented with original criteria developed by the SDSN Youth Russia team for better adaptation to the Russian context. The new criteria included challenges and needs, affiliation (university, public company, government) and the scale of contribution (federal/regional/local). As sources of information, open databases, websites of companies, social networks, and SDSN Youth Russia provided closed information on companies in a unique Google form.

3. Results

This section introduces the overall results of the analysis of the 37 youth solutions included in the Report. The results of the analysis revealed the following patterns: most of the solutions were commercial projects (51.3%), the majority of which were managed by young people under the age of 35 (72.9%) and were located in Moscow (35%) or St. Petersburg (24.3%). According to the data provided, 14 organizations were led by women (78%). In terms of duration, most initiatives had been operating for less than three years (48%) and had up to 100 employees/volunteers (83.7%). Among the 12 companies that provided data, 33% reported a budget up to $5000 (33%) and 41% from $25,000 to $100,000 (41%).

A total of 48.6% of the solutions were non-profit, 21.6% were aimed at young people, 21% conducted their activities in several cities of Russia, 10.8% were situated online, and 10.8% were based in other cities and regions of Russia. It is important to note that due to COVID-19, some solutions transformed their operational model to an online space.

3.1. The Addressed SDGs

Regarding the Sustainable Development Goals, SDG 12 was the most common goal; a total of 16 of the solutions (43.2%) acted directly on its implementation and one solution

acted indirectly for the selected youth solutions' achievement. Next, for SDG 17—seven, or 18.7%, of solutions worked directly on its implementation and one indirectly; for SDG 4—four, or 10.8%, of solutions worked directly on this and three indirectly; SDG 8 was indirectly implemented by four solutions; for SDG 3—three organizations worked on this. SDGs 1, 2, 6, 14 were not represented at all in the Report. The least represented SDGs were SDG 5, SDG 7, SDG 9, SDG 11, SDG 13, SDG 15 and SDG 10 and, indirectly, SDG 16—with one organization for each of these remaining Goals.

3.1.1. The Main SDGs Addressed

As noted above, the most popular SDGs in Russia among the commercial and non-profit youth organizations were SDG 12, SDG 17, SDG 4 and SDG 3.

The popularity of SDG 12 among youth organizations is quite remarkable. In Russia, SDG 12 is mainly associated with the issue of garbage and waste recycling. The popularity of this Goal occurred primarily due to the Russian context—since 2019, the situation in the waste recycling sector has been classified as catastrophic [2] (p. 6). Currently, 93% of garbage is sent to landfills, and only 7% is recycled [3] (p. 12). It is also important to note that the current capacity of Russian landfills at full load will be enough for only the next four years [2] (p. 6). For this reason, the waste recycling sector in Russia was and is primarily comprised of civil society, non-profit and commercial organizations.

The state took up the problem of waste recycling only in 2018, launching the federal "Integrated Solid Municipal Waste Management System (MSW)" within the framework of the national project "Ecology", in which sorting and recycling of waste had already become mandatory for the regions of Russia [4].

Thus, the popularity of this particular SDG is explained by the catastrophic situation in the garbage sector in Russia and the great public demand for the development of the system of waste recycling and the concept of responsible consumption in the future, as well as the extensive participation of NGOs and social movements in this area.

The second most targeted Goal was SDG 17—"Partnerships for Sustainable Development". In the country context, the popularity of this goal among youth NGOs and primarily commercial organizations was not unexpected; however, from an international perspective, there are several barriers to achieving it, including the political isolation of Russia from Western Europe and the United States, the lack of state programs of additional education of theory and practice in sustainable development for specialists, managers and officials, and a low level of qualification for international cooperation [5] (p. 134).

In the report, SDG 17 is addressed mainly by youth consulting companies that advise businesses and NGOs on the transition to more sustainable practices. These companies are young, have been established for less than three years, and are small, having less than 100 employees.

The popularity of such new consulting companies indicates a demand for a transition to the concept of sustainable development among small and medium-sized business corporations and NGOs in Russia. In addition, young people interested in the sustainable development agenda can realize their entrepreneurial abilities in a relatively new area for Russia. SDG 4 was represented by four non-profit youth-led organizations, which is considered insufficient compared to the two goals mentioned above. These organizations were mainly focused on teaching new disciplines, such as programming, computer science, robotics and, in particular, modernizing school education, especially in the regions of Russia. According to the SDG Progress Report 2021, all indicators of SDG 4 have been fully achieved [6] (p. 380). However, the Civil Society Review states that, currently, there are many issues in the field of education, the main one being the lack of modern educational approaches and technologies, since the entire education system is based on old standards of the industrial era [5] (p. 49).

Consequently, the same pattern was observed that has been discovered recently with other SDGs—non-profit and for-profit youth-led solutions responding to society's demands that are not currently being addressed by state political will.

The next SDG in terms of representation was SDG 3, which has a similar specificity. The Report refers to three organizations that focused on different areas of health care: assistance to children with rare diseases, psychological well-being, and new technologies in rehabilitation after surgery. All these areas are not fully addressed by state policy in one way or another or do not have adequate funding [5] (p. 43).

3.1.2. The Underrepresented SDGs in the Report

The least represented SDGs were SDG 5, SDG 7, SDG 9, SDG 11, SDG 13, SDG 15, SDG 10 and SDG 16. SDGs 1, 2, 6, 14 were not presented at all in the Report.

The SDGs underrepresented in the Report were primarily addressed to the following areas: gender equality, renewable energy, reducing inequality, sustainable cities and human settlements, climate action, conservation of terrestrial ecosystems and justice. For each of these SDGs, the Report identifies one solution. In our view, this suggests that young people are just beginning to make efforts to work on these goals, as they are either difficult to achieve through the activities of youth organizations, or they are at an initial stage of development in Russia itself. Such areas as the fight against poverty and hunger, clean water and sanitation, and the preservation of marine ecosystems are not represented at all. Perhaps this is because there is not such a high public demand for them as for other areas, or larger organizations are already addressing them.

3.2. The SDGs and Operational Model

Table 1 shows the distribution of the implemented SDGs between commercial and non-profit organizations. As can be seen from Table 1, SDG 3, SDG 4, SDG 5, SDG 7 and SDG 13 were implemented mainly by non-profit organizations. These areas are health and well-being, high-quality education, sustainable development, gender equality, clean and affordable energy, and the fight against climate change. SDG 3—"Good Health and Well-being", is represented in the Report not only by charitable organizations, but also by an online project on psychological health, and by a commercial organization engaged in developing new technologies for rehabilitation after complex operations.

Table 1. Percentage of non-profit and for-profit solutions in terms of SDGs.

Sustainable Development Goals	For-Profit	Non-Profit
SDG 3	5.20%	11.10%
SDG 4	-	27.70%
SDG 5	-	5.50%
SDG 7	-	5.50%
SDG 9	5.20%	-
SDG 11	5.20%	-
SDG 12	57.80%	27.70%
SDG 13	-	5.50%
SDG 17	26.30%	11.10%
Overall:	19 solutions	18 solutions

SDG 8, SDG 9, SDG 12 and SDG 17 were implemented mainly by commercial youth organizations. Accordingly, commercial initiatives work primarily in industrialization and new technologies, responsible consumption and waste recycling, and partnerships to achieve Sustainable Development Goals. It is important to note that SDG 8 was implemented by commercial youth organizations, not directly but indirectly, both in individual projects and related activities.

3.2.1. Non-Profit Youth Solutions: Best Practices

Exclusively non-profit organizations implemented initiatives in providing quality education in the regions of Russia, in gender equality, renewable energy and climate policy. All these organizations were not affiliated with state institutions. Only two of the NGOs had affiliations with any foundations or an international public movement (i.e., Fridays for Future). This trend is noteworthy since all the above areas do not have broad state support and are just at the beginning of attracting the attention of the public sector. According to the Civil Review on the implementation of the SDGs in Russia, SDG 5 accounts for one of the lowest percentages of coverage of the SDG tasks by national projects of the Russian Federation—only 22%, while SDG 13 and SDG 14 are not covered by them at all, according to the Russian civil community [5] (p. 29). The distribution of state programs of the Russian Federation for the implementation of the SDGs also serve as evidence: SDG 4 and SDG 13 account for the minimum number of programs—only two for each [7] (p. 26).

The characteristic features of youth NGOs contributing to the achievement of SDG 4 in Russia are their focus on youth, local contribution and their small size (up to 100 employees/volunteers).

The best practices of implementing SDG 4 by youth NGOs were:

- educational projects aimed at improving the quality and versatility of school education in the regions of Russia (e.g., the "Circle" project);
- professional development of young teachers (e.g., "Teacher for Russia");
- projects for the socialization of vulnerable groups of young people (e.g., "Uppsala Circus");
- educational projects for young people on new topics, such as gender equality and tolerance of appearance.

For other SDGs, namely 5, 7 and 13, there were a small number of projects—one for each. For this reason, it is difficult to identify the best practices for their execution.

A small percentage of youth NGOs also implemented SDG 12 and SDG 17. Non-profit initiatives under SDG 12 were aimed at:

- organizing the collection of recyclable materials from the population;
- educational events concerning the importance of sorting and recycling of waste;
- sharing second-hand items ('reuse').

Two youth NGOs were engaged in developing a partnership for sustainable development (SDG 17) by implementing an educational initiative for young international specialists (the Academy of Youth Diplomacy) and volunteer programs aimed at implementing various SDGs.

3.2.2. For-Profit Solutions: Best Practices

The Sustainable Development Goals that were implemented mainly by commercial companies, were SDG 8, SDG 9, SDG 12 and SDG 17. It is worth noting that SDG 8, "Decent Work and Economic Growth", was implemented not directly but indirectly as separate projects of organizations. With respect to SDG 9, "Industrialization, Innovation and Infrastructure", this was implemented by only one youth-led company, which was engaged in developing and producing a new cleaning powder technology to minimize environmental damage in the industrial sector. Most of the commercial initiatives were represented by SDG 12 and SDG 17.

Youth commercial initiatives under SDG 12 involved a wide variety of forms of solution:

- production and sale of products from recyclable materials;
- enterprises that adhered to the waste-free provision of services (e.g., beauty salons, shops);
- sharing initiatives (e.g., reusable glasses for drinks in cafes, an application for selling left-over food from restaurants at a discount).

Youth for-profit solutions that operate with an SDG 17 focused on "green" consulting and seeking to make sustainable businesses one united system.

The best practices of for-profit solutions in the field of SDG 17 in Russia were:

- consulting for businesses and NGOs on the transition to eco-friendly operating models;
- conducting business seminars on the implementation of the SDGs in operational activities;
- holding forums among commercial companies that have implemented the SDGs in their operational activities;
- combining eco-businesses into one consumer-friendly system.

3.3. Challenges Faced by Youth Organisations in Russia

Based on a survey conducted by SDSN Youth Russia among the initiatives and solutions in the Report, the main problems for SDG-oriented solutions were the following:

- particular solutions struggled with finding and establishing long-term partnerships (both experts and related organizations);
- more than half of the respondents mentioned finding professionals with IT skills was "not easy", especially people who could "professionally" use technologies and online tools;
- public and private financing was one of the most common issues that respondents highlighted in the survey as well—overall, 44.4% of initiatives identified these two as necessary.

We also discovered that these issues were similar to common problems that youth initiatives face in various countries on a global scale. The following challenges have been worsened by the COVID-19 and its impact on the progress in SDGs.

Firstly, unpredictability, which is defined in the Report as the lack of capacity to get access to relevant and reliable information on SDG implementation and technologies due to the fragmentation or lack of essential elements of support for SDG-oriented initiatives in the social field. Secondly, implementation, as some initiatives go beyond the context of socio-political life in the regions of Russia (such as, for example, projects to maintain gender equality or environmental projects). Thirdly, governance, which relates to the difficulty of financing SDG-directed projects through grants or direct support.

4. Discussion

The results obtained from the analysis of youth initiatives provide a meaningful foundation for future discussion on youth solutions in Russia. The most represented youth solutions were for those SDGs for which there is a vibrant and relevant social demand and an urgent issue that is not yet addressed by the state apparatus to one degree or another. Such solutions are also characterized by the fact that they operate where large scale organizational activity is not required; however, they arise where it is feasible to make a local or regional contribution to solving an urgent issue.

The most common practices of the SDGs implementation among youth non-profit organizations were various educational events and lessons, projects for the socialization of vulnerable groups of young people, and 3R projects (reduce, reuse, recycle). Commercial youth enterprises worked mainly in the b2b sector to provide sustainable business solutions, sell or produce environmentally friendly goods or to develop new, more sustainable technologies for various economic sectors.

Thus, the social demands expressed in the concept of the Sustainable Development Goals have created new areas of activity for both for-profit and non-profit youth organizations in Russia. Commercial initiatives are the most promising, as they have greater coverage and work in unoccupied areas of the Russian market. This fact suggests the growing potential for the development of SDG-focused youth entrepreneurship in Russia.

Youth non-profit organizations act first as a specific response to the very social request formulated by the Sustainable Development Goals, in relation to which they undertake specific tasks and have mechanisms for solving urgent problems locally.

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Export-Readiness Assessment for Ramón Seeds in the Maya Biosphere Reserve Communities (MBR) in Péten, Guatemala: Optimized Export Capacity Enabling Resilient Livelihoods †

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Abstract: The success of the existing Mayan Biosphere Reserve (MBR) model depends in large part on the resilience and sustainability of forest livelihoods within MBR communities. Concession livelihood strategies include and often depend on the trade of non-timber forest products, within and outside the region. Of particular interest is Ramón seed, which is used as a food crop and an ingredient in food and beverages in national and international markets. This research focuses on strengthening community forest enterprises and on supporting and expanding market opportunities that contribute to local livelihoods by presenting an export-readiness assessment for the Ramón seeds' export to the US market. We explore the resiliency of community forest enterprises in response to economic and environmental vulnerability, such as the variability of wild-sourced Ramón seeds. Variability in supply, in the ability to harvest, and in post-harvest processing have substantial effects on market success. Considering this, understanding the resilience of these Agri-forestry enterprises will support community desires to sustain and improve their livelihoods.

Keywords: export-readiness; Mayan Biosphere Reserve; Ramón seeds; resilient livelihoods

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1. Introduction

The Ramón nut is a local product that has been used in Peten since the Mayan civilization. The extraction, processing, and commercialization of the Ramón nut locally, as well as selling it to a third-party (intermediary partner) to sell the Ramón seeds to international markets is one of the ways that the Maya Biosphere Reserve communities manage to gain better livelihoods.

Our main goal with this paper is to increase the value-added exports from the local communities in Peten, Guatemala to global markets. To accomplish this goal, we examined different processes, frameworks, and standards of non-timber forest products (NTFPs), focusing on Ramón, to assess these communities' ability to export to the global market, specifically the U.S. market. This work serves as a pilot study for assisting the Rainforest Alliance in conducting a full-scale export development framework for the whole concessionaires in Peten, which can be implemented through future graduate students' work. In this report, we attempt to tackle the following questions: What do we mean when we say that the community forest enterprise is "export-ready" as a responsible business? How can communities identify the export gaps of their production of Ramón to be ready to penetrate the U.S. market? What conclusions might we draw from the various methodologies and approaches undertaken to assess the export-readiness of Ramón?

This report includes the methodology that we used to undertake the export-readiness assessment, as well as the techniques used to gather the data used in this research. Following the Methods section, we discuss the findings and, finally, we share our preliminary findings.

2. Methods

To identify and evaluate the export-readiness and capabilities of involved local communities and community partners to export Ramón into the US market, we decided to use a mixed-methods approach to collect and analyze the data. This is due to the complex nature of the subject, considering the nature of the concession's framework, through which the economic and social impacts on these communities residing in the Maya Biosphere are generated out of their harvesting and commercial activities.

Throughout the research process, the selected methods were non-linearly modified to adapt to the realities of the local communities and the limitations of time we faced during the summer field work. The consultants worked on three phases: the first phase included developing the export-readiness questionnaire forms, the methods for application, and the assessment and evaluation techniques. The second phase was the implementation of the designated methodology. Lastly, the third phase involved carrying out the export-readiness evaluation and analysis.

As the export-readiness assessment was new to this project and the project client 'Rainforest Alliance', we conducted a pilot testing questionnaire interview with one of the stakeholders, which helped the consultants establish "whether or not the method of data collection, as well as the questions being asked, are eliciting target responses" [1]. Hence, several questionnaire forms were developed to fit the role related to each stakeholder involved in the export value chain. The methods that have been and will be used to ensure that the research results will be used includes involving Rainforest Alliance and other stakeholders in the design and hopeful implementation of the report, ensuring that everyone has a "vested interest", maintaining the project team's credibility, and maintaining open and honest communication [2]. Throughout this process, we had various meetings with Rainforest Alliance and the community partners. They also provided important feedback consistently throughout the analysis and assessment process. Methods of communication with the client included emails, working Google documents allowing for open feedback, memos, and meetings [2].

In this research, we are targeting a diverse set of key stakeholders involved in the Ramón export value chain, from the Ramón community harvesters to Ramón seed aggregators, the Ramón exporter, and the U.S. Ramón importer. The aim of this wide segmentation in our sampling plan is to capture a holistic understanding and evaluation of the current export value chain, based on the different experiences of these stakeholders. The evaluation process depended on the data obtained from semi-structured questionnaires and secondary data sources, such as financial and business documents received from the participants and field observations, to generate confirmatory results.

With regards to the use of qualitative techniques in this research to collect data and to understand the capabilities and readiness of the value chain of the Ramón seed, we developed our questionnaires by consolidating some of the questions used in export-readiness assessment implemented by two international organizations: the United States Agency for International Development (USAID) and the Centre for the Promotion of Imports from developing countries (CBI). These organizations are devoted to promoting the transition towards inclusive and sustainable economies globally through the expansion of fair and universal trade. This reconciliation of ideas from the successful practices of ERA was based on the selection of the most positive and relevant aspects of each of these methodologies that matched the socio-economic characteristics and realities of community forest enterprises in Mesoamerica.

To answer the questionnaires, we used a non-random sampling method to find preselected participants who are key informants of the stakeholders related to the supply chain of the Ramón seed. Due to the technical nature of the questionnaire's questions, our inclusion criteria to choose the respondents of the questionnaire includes that the interviewed person had to have a role in the export value chain of the Ramón seed. We involved some demographic criteria related to gender and occupation in our sampling structure. In that context, our target sample size was 20 participants, including 7 female and 7 male Ramón

harvesters, the President and Vice President of the Ramón committee, 1 representative of the concessionary association, 1 representative of ACOFOP (as a community partner), the co-founder of Cafinter (one of the main Ramón exporters), and the founder of Teeccino (one of the main importers of Ramón in the U.S.). However, due to time limitations and COVID-19 restrictions, we were able to apply for 13 interviews with 3 different stakeholders in two different concessions (AMUL and Uaxactum).

To analyze the social and economic impacts of the export activity of Ramón, we conducted in-depth semi-structured interviews with the interviewees to analyze their perspective on the export of Ramón and the difficulties they face all over the Ramón export chain. During the interview, the consultants spent considerable time probing participants' responses, encouraging them to provide detail and clarification. These data, along with field observations and submitted commercial documents from community partners, were critically analyzed and then evaluated to provide an overall assessment of the communities' capacity and capability to export Ramón to the U.S. market; this is along with secondary data from desk research, as well as previous university alumni works, which were used to explore the findings.

3. Results

During the interview process, we had the opportunity to understand how the stakeholder value chain works for Ramón in the communities of the Mayan Biosphere. It was possible to both access the existence of different stakeholders and to understand the importance of each of them in the Ramón chain, as well as their importance to one another.

Farmers or Ramón collectors are people who live in the communities and have the Ramón activity as part of their livelihood. Part of the household incomes of said farmers come from this activity. In the case of Ramón seeds, the farmers are at the base of the chain. They are the most affected by any type of change in the chain, be it price changes, demand changes, or even external factors related to nature. Thus, they are essential for the supply chain, although they are the last ones to feel the improvement of the business factors and the first ones to be affected with the improvement of socioeconomic attributes [3].

To understand how and why the farmers live in those areas, we need to explain the concept of concessions. The concessions, or forest communities, of Petén protect 70% of the Mayan biosphere reserve, which has 2.1 million hectares of forest full of biodiversity and resources (ACOFOP, 2020) [4]. These concessions are government authorizations given to pre-existing communities that resided within the Mayan Biosphere reserve. It is important to state that each community has a different background and formation process. The existence of community companies in the Maya Biosphere Reserve in Petén, Guatemala generates environmental benefits for society and socioeconomic benefits for the communities and, in return, the government grants the rights of use and management of those resources [5].

Each community/concession is legally represented and constituted by an association, which is the legal actor representing the community. They can be called concessions, associations, or community companies, and are legally responsible for the rights and duties constituted by the concessions. The community companies have their own statutes and hold regular elections to elect their administrative body. Studies show that there is evidence of positive environmental impacts and advances in the socioeconomic sphere, together with the documented evidence of positive environmental impacts (deforestation rates close to zero in active community concessions), and a positive relationship between advances in the socioeconomic sphere (income, investment, savings, capitalization of community enterprises, asset formation of associated families and organizations) [5].

As a way to increase their bargaining power with potential customers, these associations understood that together they had more strength. In this way, the joining of associations and partner organizations created the Ramón committee. The committee is a place to debate and define opportunities, challenges, and prices. As mentioned, the committee is formed by the organizations and institutions that help and support the farmers

and the associations. The committee is an institutional place, allowing them to obtain more voice and power in front of clients and bureaucracies and, thereby, become stronger.

To organize their forest services, they created FORESCOM: a community forest services company that emerged because of the expansion of 11 community forest concessions in Petén. The company sells wood and non-timber forest products under strict world standards, which guarantee the sustainability of natural resources managed by community forest concessions in the Mayan Biosphere Reserve, and at the same time generate employment and social development for Guatemala. In the Ramón supply chain, the communities collect the Ramón seeds and take them to FORESCOM to be dried in an oven that belongs to FORESCOM. Once the work is finished at FORESCOM, the communities send the Ramón seeds to the distribution center. At this stage, FORESCOM is solely a service provider, and is related to marketing and commercial support.

Meanwhile, ACOFOP is an organization also established by the community associations to protect the biodiversity and the architectural and cultural heritage of the Mayan Biosphere Reserve. This objective is accomplished through the application of a community forestry model that, in addition to conserving, also generates economic and social benefits for those living in and caring for the woods, taking advantage of the resources of the forest, and for the management of tourist services. ACOFOP is the political and social arm of the communities and represents them in the Ramón committee meetings. ACOFOP helps the communities obtain funding that supports them in terms of training for the communities, but they are not involved in the marketing (the commercial) piece.

When the Ramón seeds are dried, the community enterprises sell them to Cafinter, the main distribution partner for Ramón seeds in Guatemala. The relationship of associations with CAFINTER is old and reliable. However, because of the way the system is established, there is not much room for new orders, making this relationship dangerous in the long term because it is just a single demand. For the commerce and distribution of the seeds in the United States, Cafinter sells them to their main buyer and distributor abroad: Teechino. Both distributors and intermediary buyers have a risky relationship in this system, as they are very dependent on each other and do not have much room for flexibility in terms of demands and orders.

3.1. Export Value Chain

The export value chain model that we used was inspired by the market value chain approach implemented in the USAID report for Kenyan specialty Coffee in Bangladesh [6]. There are many important interactions assumptions that make up the Ramón supply chain and that contribute to the functioning of the whole operation. The enabling environment that we refer to in Figure 1 involves the existence of socioeconomic attributes and business factors that enable this whole operation to exist. It is important to mention that, since the beginning of the operation, the Ramón chain has as its ultimate objective the conservation of the environment and the promotion of better livelihoods for the population that lives in the concessions of the Mayan Biosphere. The social factors are equivalent to the existing social mobilization around the Ramón-associated economic activity, the improvement of the quality of life of the community, and the constant preservation of the environment through the execution of management plans and audits to maintain the concessions.

A common topic brought up in the interviews was that, because of the existence of the Ramón activity, the community was able to improve the quality of life of its citizens, particularly for both the people who actively participate in the harvest and sale and for people who are not directly involved but who are also benefited, such as small business owners and small service providers. The business factors are related to the Ramón market's trend and demand for the product. A point recurrently mentioned in the interviews is that, now, it is only possible to start harvesting activities after a purchase order is confirmed. Thus, movement in this context becomes codependent on the market. The export value chain is made up of actors and assumptions that contribute to the harvest and delivery

of the product, from the creation of the management plan to the inspection of favorable locations for harvesting.

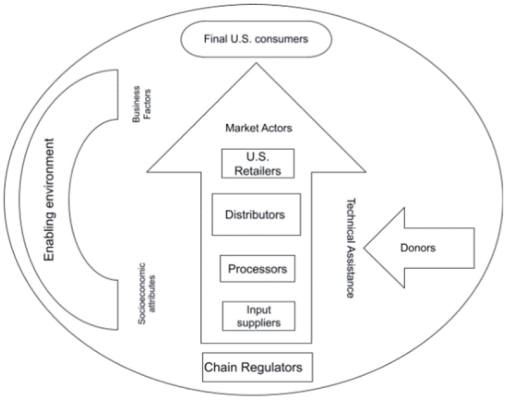

Figure 1. Ramón export value chain conceptual framework.

3.2. Export-Readiness Assessment (ERA) and Resilient Livelihoods

Based on the existing literature about export-readiness, we identified that the three main requirement areas are organizational capacity, operational and technical capacity, and community resilience factors. We found that organizational capacity and the operational and technical capacity assessments alone are not enough to address the U.S. market needs in a socio-economic context. Organizational capacity along with operational and technical capacity are key to ensure an effective and sustainable export performance of any enterprise. However, community resilience and benefits are essential for business strength and durability. In that manner, we have identified the export requirements for the Ramón product as a specialty food based on desk research and other secondary resources.

We assessed the requirements with the current situation to highlight the export gaps that need to be fulfilled by the Ramón committee, with the assistance of the Rainforest Alliance and FORESCOM as well as intermediaries involved in the export value chain. Figure 2 illustrates the export requirements identified as organizational requirements and product requirements.

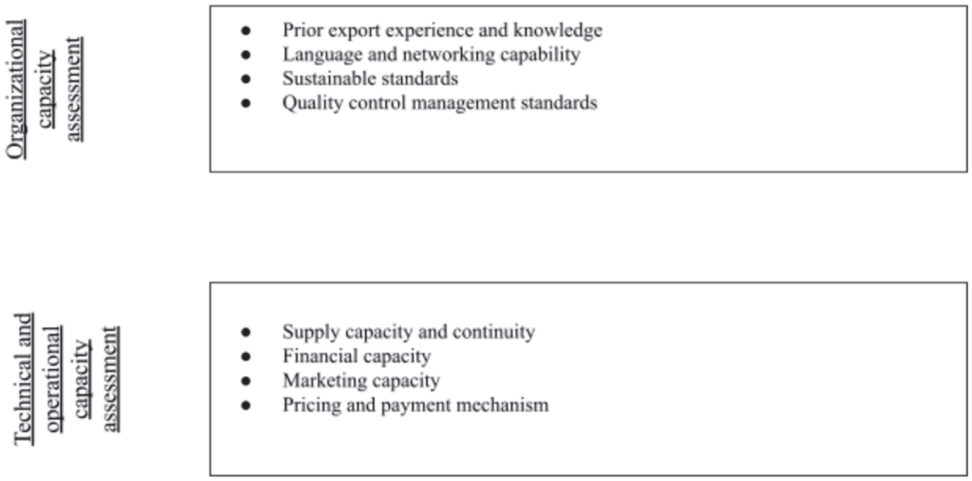

Figure 2. Export-readiness assessment—organizational and technical and operational assessment.

3.2.1. Organizational Capacity Assessment

Prior Export Experience and Knowledge

The assessment factor here is whether the Ramón exporting intermediaries have prior export experience and knowledge. Unawareness of the U.S. trade and food safety regulatory framework, which is known to be very bureaucratic, could hinder a successful business's

attempts to enter the export market. Thus, we think that having at least an experienced Ramón exporter to the U.S. may benefit from lower trade costs over time, due to export experience. In addition, this exporter might be the driving force for new exporters to be encouraged to enter the export market of Ramón by observing the experienced exporter's decisions and learning from his market entry strategies.

The Ramón exports take place through indirect exporting via an intermediary private enterprise named Cafinter S.A., who has been involved in that activity for about 15 years. The owner's experience in navigating the global marketplace and bureaucratic trade requirements for other products aside from Ramón plays a key role in facilitating the process of exporting Ramón to the U.S. market. Exporting Ramón through indirect exports removes the burden of being involved in rigorous export-related administrative and logistical operations from the concessionary communities. It also helps them obtain accelerated access to the U.S. market without requiring any expertise or major cash expenditures, which is suitable for the concessionary communities who are not familiar with exporting.

Language and Networking Capability

The language and networking capability is another key factor we have considered in our assessment. Having a staff member with adequate English language skill is essential for conducting business with U.S. importers and their intermediaries. Moreover, networking skills are required for trust-building with U.S. importers. This can be met with adequate knowledge of the business ethics and culture of the international client. It also requires the exporting committee to be fully knowledgeable of its Ramón product market attributes, to build rapport with their prospective U.S. clients while convincing them to import Ramón.

Sustainability Standards

Certifications for non-timber forest products aim to accomplish the 12th goal of the United Nations' SDGs (responsible production and consumption) by providing an accountability tracking process through which consumers understand the environmental and social impacts of their consumption habits [7].

An enterprise can purchase a sustainability-related certification for its forest produce to broadcast its responsible purchasing decisions. Consumers choose to purchase these eco-friendly certified products because they want to contribute to the promotion of a more sustainable world by taking responsible and ethical decisions through their purchases [7]. For some target export countries, such as the U.S., it goes beyond the above-mentioned voluntary schemes. Ramón's producers already have the organic certification because they are subject to obtaining such certification in order to sell their produce in the U.S. legally, which is one of the main consuming markets for organic-certificated products.

The fair-trade certification set by the Fairtrade Labelling Organizations International (FLO) is an important certification standard, as it guarantees a minimum price to producers, being exclusive to smallholder farmers. The US is the largest fair-trade import market, with 85% of its imports coming from Mexico and Central and South America, where a considerable number of consumers are advocates of responsible production and business practices. Thus, having a combined fair-trade and organic certification for Ramón would serve as evidence to conscious U.S. consumers that they are being paid fairly and, hence, they will be encouraged to take part in sustaining their livelihoods by purchasing Ramón.

Quality Control Management Standards

Through field observations and interviews with farmers and the community association's staff, it was possible to identify the procedures related to quality control established throughout the Ramón supply chain. For the interviewees involved in the harvesting process, the quality standards for that part were well known and established, following the criteria that harvesting should only take place in pre-demarcated areas. For the demarcation of the areas, there are Ramón's collection supervisors that determine where the harvesting should take place; the harvesting process involves selecting only whole seeds, without any

type of cracks or damage; washing the seeds so that no dirt remains; drying the seeds in an airy place, and storing them away from impurities until the day of sale to the associations.

Regarding quality certifications, the Ramón seeds produced in the Mayan Biosphere have two quality certifications: the organic certification and the kosher certification. The organic certification states that all the materials involved in the production of Ramón's seed were of organic origin, while the kosher Certification assures that both the product and its production process adhere to all kosher law requirements.

3.2.2. Technical and Operational Capacity Assessment

Supply Capacity and Continuity

The supply capacity of the operation is related to the capacity of the concessions to supply the demand informed by the market. In the current state of the operation, the concessions' ability to supply market demand depends directly on three variables: (1) the harvest period for Ramón trees; (2) the storage capacity; (3) the cash available for working capital.

The harvesting period for Ramón seeds happens twice a year, once around March and again around September. The harvest season lasts approximately one month. The harvesting period appeared several times in the answers of several interviewees as a determining factor of the amount of Ramón available to the market and the conditions in which they harvested the seeds. According to a female harvester from Uaxactum, the number of seeds available and the time they will be available depends on when and how those harvests are going to take place. The same interviewee goes on to say that, "climate change affected the harvesting season. We cannot be 100% sure when the harvesting season is going to be. It is more unpredictable". Most of the harvesters we interviewed from the Amul and Uaxactun committee claimed that climate change interferes with the number of seeds available for harvest.

With regards to the storage capacity, one of the interviewed female harvesters commented that, in 2020, during the pandemic, the communities had a very good harvest, but they could not sell much of what they collected because the associations no longer had a place to store the harvest. The interviewee also explained the reason this happened. According to the interviewee, during the pandemic, the demand for Ramón seeds fell far below normal, which caused this problem. ACOFOP's representative also declared that FORESCOM is able to store around 342 to 400 "quintales" of green Ramón seeds at the moment. They are also able to store 1000 "quintales" of dried Ramón seeds, and are working on creating more space so that the communities can store their produce for future sale. In this way, the problem now is to secure enough working capital to pay the workers for the harvest before receiving the payments from the clients for it.

In addition to what has already been discussed on the matter, having working capital to pay the workforce is a recurrent problem in the communities we interviewed. One of the interviewed harvesters from the Amul committee noted that this is a recurring problem. According to the interviewee, the associations only have enough resources for working capital when they close a deal, which means that even when there is production, if there is not a known demand, the Ramón seeds cannot be bought by the associations; or, when they are bought by the association, they are bought at a much lower price than usual, as was also the case during the pandemic.

Financial Capacity Assessment

The access to working capital was a major difficulty identified during the research. Because of that, it is important to analyze that the availability of financial resources related to financing working capital for these communities so they can cover export investments and relevant contingent expenses. To match the non-profit and social contexts behind this export activity, we considered the availability of grants provided through the channels of community partners such as ACOFOP and the Rainforest Alliance, to support the export business of these communities as a component of this financial capacity assessment. This is in addition to the reinvested profits from their Ramón sales to make the business self-

sustainable; it also includes the accessibility to bank credits and whether they are obtained easily. These financial resources are not only needed to fulfill the export requirements, but also for indirect costs such as operational or marketing expenses, which are also important for ensuring the self-sustainability of the export business of these local communities.

ACOFOP has access to funding from several bilateral donors and foundations, such as USAID, the Ford Foundation, and the Overbrook Foundation. The projects financed by those institutions are generally 2–3 years long, which means that they must write proposals continuously to keep the projects operative. The interviewed ACOFOP representative staff argued that the organization is doing a really great job maintaining continuous support for the programs that already exist. Due to the nature of the venture developed by the communities, they have access to a different category of loans from funding programs with zero interest rate. With those loans, the communities only need to pay back the money they received. This kind of loan works as a payment for environmental services to help forest conservation efforts and to empower community enterprises to bring them up to speed.

Pricing and Payment Mechanism

Many harvesters who have been interviewed complained about the pricing and payment for their Ramón yield. The pricing does not cover the risks they are exposed to in their harvesting activities, such as being exposed to snake bites and harmful bugs. This is in addition to overcoming the long distances they must cover in order to reach the harvesting areas, as there is no availability of cars to transport them to these harvesting sites. Female interviewees were the ones who complained most about the pricing systems, claiming that they are the most vulnerable to the harvesting activities due to their lack of access to adequate transportation facilities and harvesting equipment that helps them with harvesting, especially during heavy rainfalls, imposing risks on their lives as well. Additionally, the current pricing system does not allow them to benefit from the price increases of the U.S. market, going against the ultimate goal of the whole Ramón operation in the Mayan Biosphere Reserve communities of optimizing their livelihood. Moreover, a female harvester and quality control inspector in the Uaxactun community mentioned that they struggle with price changes set by the community association, which is responsible for collecting their Ramón produce to be prepared for the exporters. The harvesters are not involved in the Ramón resource management due to the lack of a formal contractual agreement on pricing and purchasing that guarantees their reward rights. Many of the harvesters who have been interviewed mentioned that their Ramón collection activity is important for securing their livelihood and for sending their children to schools and colleges. So, if harvesters are not being well-compensated for their hard work in Ramón collection, it might impose a risk on the continuity of the Ramón export business.

Marketing Capacity

The Ramón organic certification is one of the many ways that Ramón producers can increase their U.S. market access and penetration. Additionally, sustainability in sourcing and along the export value chain brings direct benefits to people and nature, while bringing business benefits as well. Many research studies have demonstrated the positive business impacts of putting sustainability standards into their marketing business strategy. For instance, 98% of businesses experience sales and marking benefits after adopting sustainability standards. Such benefits include areas such as improved reputation (60%), increased profitability (53%), cost reduction (30%), and increased production (30%). Moreover, 78% of US household heads feel better when purchasing products that are sustainable or better for the environment.

4. Discussion

Based on what we have studied, we believe that the community forest enterprise will become "export-ready" as a responsible business when it manages to export and maintain its capacity to meet international demand, thereby improving the lives of people who

live in the community. Based on what we heard in the interviews and the documents we analyzed, we can point to the following proposals for improving export gaps as well as strengthening communities:

4.1. Profitability Mechanism

Adjust the pricing regime: the Ramón committee, FORESCOM, and ACOFOP can start finding other buyers or negotiating the pricing with existing buyers, subsequently benefitting the harvesters. A variation on this indirect exporting channel is the use of e-commerce platforms to sell Ramón directly from communities through FORESCOM. There should be a profit-sharing mechanism that allows the Ramón harvesters to share the benefits of higher Ramón export returns.

4.2. Value Chain Traceability

Currently, market needs are rapidly changing as consumers' consciousness is developing day by day; hence, consumers have become highly interested in looking for sustainably and responsibly produced goods. In that sense, simple marketing claims might be no longer sufficient to assure the sustainability of Ramón production. We think that inserting an integrative monitoring system would optimize the export value chain in two areas. The first one is the ability to access good data throughout the value chain relating to Ramón harvesting date and location, quality, and inventory tracking, so as to help the Rainforest Alliance and other community partners make more informed decisions. The second one is increasing the community profitability of Ramón by raising customer satisfaction and confidence in the product quality and the responsible production process.

4.3. Community Leadership

Appropriate institutional arrangements that allow shifting the authority over Ramón resource management backwards, in the direction of small community harvesters, by involving them in the production, processing, and pricing activities.

4.4. Harvesting Operations

The Ramón harvesting operations need to be optimized. FORESCOM and RA need to devote funding towards working capital, including Ramón seed collecting equipment, to ensure safer and efficient harvesting operations for the community harvesters. This would also help the communities overcome the Ramón supply vulnerability problem, as it would allow the communities to safely access risky Ramón harvesting areas without being attacked by snakes. The working capital funding also needs to include trucks that can safely transport communities to and from the harvesting areas, especially during heavy rain falls. Moreover, the local communities need more funds from community partners to finance warehousing facilities, to allow them to store and process Ramón seeds themselves without passing through several intermediaries, thereby providing them with some sort of agency, which is essential for optimizing their Ramón export produce, as well as for benefiting from the markup price difference to sustain their livelihoods and resilience. Therefore, we believe that less dependence on third parties in the export process can strengthen communities and their businesses.

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Environmental, Economic, and Health-Related Impacts of Increasing Urban Greenery Cover †

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Abstract: An integrated approach, including statistical data elaborations and microclimate simulations, was presented in this paper to assess the impact of increasing the urban greenery cover in two communities in Ontario on the urban environment, air quality levels, health, and economic responses. The study also aimed to prove the association between ambient temperature and air quality. The correlations between meteorological parameters and air pollutants showed that the ozone and fine particulate matter daily mean concentrations are positively correlated with the mean temperature. The increase in the urban greenery cover confirmed a reduction in mean air temperature of 2 °C and daily average energy savings of 0.16 kWh/m^2. With the linkage to other responses, the results demonstrated a potential enhancement in all-cause mortalities and economic benefits.

Keywords: urban climate; air quality; heat-related health; green infrastructure; microclimate analysis

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1. Introduction

The combination of climate change, Urban Heat Island (UHI), and heatwave events leads to higher daytime temperatures, causes excessive heat stress for urban dwellers, and increases heat-related mortality [1,2]. Meanwhile, the consequences of the UHI and the frequency and duration of heatwaves around the world are becoming more evident [1,3,4]. The Canadian Environment Health Atlas (CEHA) and the Toronto Public Health Department estimated that 120 people die in the Greater Toronto Area (GTA) annually because of high temperatures. The predictions indicate that heat-related mortality will be doubled by 2050 [5]. The correlations among temperature, humidity, poor air quality, health issues, and benefits have been proved in recent studies [6,7]. In a recent Spanish study, the effect of climate change was shown to increase the annual air pollution deaths and reduce the health benefits by 10% [8]. Moreover, a significant correlation was found between extreme heat stress and poor air quality conditions with increased concentrations of O_3, NO_2, and SO_2 [9]. Therefore, applying heat and air pollution mitigation strategies that protect human health and improve the urban environment is essential for urban dwellers [10]. Increasing the urban greenery, which includes vegetation, tree canopy, and building vegetation elements, influences the urban canyon thermal environment and the air quality as an evolutionary and efficient UHI mitigation [11–13]. Meanwhile, preserving and maintaining the greenery cover of the protected natural land, the so-called Greenbelt, and river valleys in Ontario helps in decreasing the ambient temperature and biogenic emissions and promotes the increase in evapotranspiration and shading.

Most of the reviewed studies ensured the great potential of increasing urban greenery cover for reducing ambient temperature and enhancing air quality levels. However, the holistic impacts of poor air quality and heat events on environmental and community responses are not well established. This paper aims to prove the association between ambient conditions

and air quality variables within the GTA and reflects the effects of adaptation and mitigation strategies on environmental and community responses. The paper uniquely discusses the expected air quality and heat-related responses regarding the proposed enhancements in the urban microclimate. These responses holistically include the environmental, energy, health, and economic benefits. This study approaches the linkage among air quality, weather conditions, and health to holistically interpret the potential of mitigation strategies to improve the urban microclimate. A novel integrated statistical–simulation approach was developed to test the benefits of increasing the greenery cover around the GTA to the urban microclimate, energy, and community responses. Following a holistic perspective, the multiple impacts of air quality and ambient conditions within the GTA were discussed. The results can be used by decision-makers to initiate policies to improve living conditions for urban dwellers.

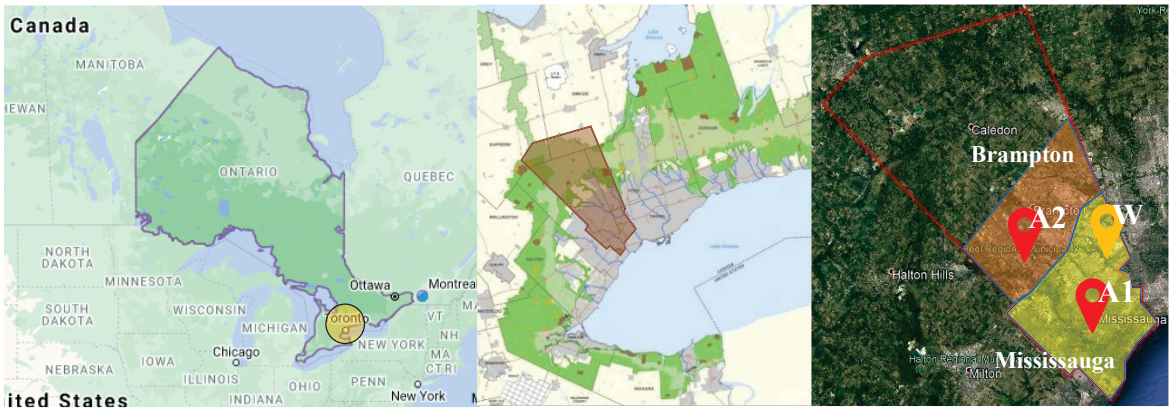
2. Materials and Methods

The method combined the statistical approach with microclimate simulations to investigate the impact of increasing urban greenery cover on the air quality and heat-related health responses. Firstly, the study intended to correlate the behavior of the meteorological parameters with the air quality variables to investigate the effect of heat-related variations on the concentration of air pollutants in the region of study. The proposed study parameters included meteorological parameters (air temperature and relative humidity) and air pollutant concentration (ground-level ozone, O_3, and fine particulate matter, $PM_{2.5}$). A statistical approach was introduced, including regression analyses for establishing the correlation between the study parameters. Then, microclimate simulations were designed using a developed and validated simulation code to assess the impacts of intensifying the greenery cover on the urban microclimate. The outputs of the predictive regression analysis and the microclimatic simulations were linked to concluding the impacts on air quality and human health response in the GTA.

Daily mean values of the meteorological and air quality variables were considered to assess the effect of meteorological parameters' variations on air quality levels in the study region. The concentration of a single pollutant was considered as the dependent variable of the regression analysis. The independent variables of the model included the meteorological parameters and the concentration of other pollutants that can affect the correlation. The statistical model was built in both Microsoft Excel and JASP software to analyze the provided dataset using multiple regression analyses. The designed model provided evidence-based correlations between the parameters, promoting the predictive potential for further estimations. Before establishing regression modeling, critical regression assumptions diagnostics were conducted, including correlations between model variables, multicollinearity, autocorrelations, and variance. The model was adjusted to satisfy essential regression assumptions.

The modeling approach included investigating the cooling and warming effects associated with the increase in urban green cover. The study utilized an updated version of the microclimate simulation code of the Urban Weather Generator (UWG) that was initially created by Bueno et al. [14]. The UWG predicts the microclimate changes in a selected urban environment compared to the weather data from a nearby rural/airport weather station to assess the effects of the UHI on a local neighborhood scale. The multi-layered, three-dimensional code considers dynamic surface temperature, shortwave and longwave radiation fluxes, and sensible heat fluxes from roofs, walls, and roads. The model aggregates the fluxes into the exchange of momentum and energy between the urban surface and atmosphere. The model was improved by the authors to update the mitigation effect of the greenery cover considering the shading and evaporation effects on the urban microclimates. Additionally, new urban and building features were developed to allow the integration of novel mitigation techniques, such as green roofs and vegetated facades. All the details of the model development and validation can be found in [15]. Thus, the model could assess the mitigation scenarios associated with the urban green strategies which include tree canopy, vertical vegetation façades, and green roofs.

According to the Canadian Council of Ministers of the Environment (CCME), O_3 and $PM_{2.5}$ are the first two pollutants that are of concern to the air quality management system in Canada. Referring to the CCME's air quality report, exposure to O_3 and $PM_{2.5}$ causes respiratory symptoms and reduced lung and heart function, with an increasingly high risk of emergency cases of respiratory or cardiovascular issues for sensitive populations (children, the elderly, and people suffering from chronic diseases) [16]. The study domain, shown in Figure 1, includes the Peel region, focusing on Mississauga (Mis) and Brampton (Brm) municipalities. Mississauga is characterized by higher urban densities, and Brampton is more characterized by the dispersal of river valleys.



(**a**) (**b**) (**c**)

Figure 1. (**a**) Province of Ontario, (**b**) Peel region regarding the Greenbelt, (**c**) municipalities of Brampton and Mississauga regarding Peel region, showing the locations of the weather station (W), and the air quality monitoring stations in Mississauga (A1) and Brampton (A2).

The air quality and weather data were obtained from the Ministry of the Environment, Conservation, and Parks, Ontario [17] and Environment Canada [18], respectively, for 12 years from 2006 to 2017. This study only focused on warm and hot seasons, which extend from May to September each year. The historical hourly concentrations for O_3 and $PM_{2.5}$ were collected from Mississauga and Brampton air monitoring stations (43.55 N 79.66 W, and 43.70 N 79.78 W, respectively), shown in Figure 1. The weather data were obtained from the international airport weather station (43.67 N 79.63 W), which represents the only available historical weather data in the region of study that cover the intended period of study. Mississauga and Brampton air monitoring stations are located 14.4 km and 11 km, respectively, away from the weather station. However, all the stations share the same urban surroundings in terms of urbanity level and urban texture. The air monitoring stations provide hourly observations; thus, daily mean concentrations were calculated for the selected period. The daily weather parameters include mean values for ambient temperature and mean values for relative humidity.

3. Impact of Meteorological Variations on Air Quality

The regression analysis was conducted including the pollutant's daily mean concentration as a dependent variable, while the mean temperature, relative humidity, and the other pollutant's mean concentration were included as model variables. The results of the multiple regression analyses for both pollutants in Mississauga are presented in Table 1. It can be inferred by the coefficients of the variables that the O_3 concentration is more correlated with the variations of $PM_{2.5}$ concentration, and with the mean temperature at the second place. With a significant *p*-value, the model shows a significant positive correlation between O_3 average concentration, mean temperature, and $PM_{2.5}$ mean concentration. Meanwhile, a significant negative correlation is observed between O_3 average concentration and RH mean value. Considering the $PM_{2.5}$ average concentration as a dependant variable, the

model shows a significant positive correlation with O_3 average concentration, mean temperature, and RH mean value. It is noticed that the most effective variable in predicting the $PM_{2.5}$ concentration is the mean temperature. In both models, it is noticeable that the RH mean value is the least influencing variable on predicting the pollutants' concentration. The predictive regression equations can be expressed by Equations (1) and (2) for predicting O_3 and $PM_{2.5}$ mean concentrations, respectively. It can be concluded that for every degree Celsius increase in the mean temperature, giving other variables as constants, the O_3 and $PM_{2.5}$ average concentrations are expected to increase by 0.34 ppb and 0.43 $\mu g/m^3$ on average, respectively.

$$O_3 \text{ avr. conc.} = 0.338\ T_{mean} + 0.736\ PM_{2.5\,avr} - 0.255\ RH_{mean} + 32.411, \quad (1)$$

$$PM_{2.5} \text{ avr. conc.} = 0.429\ T_{mean} + 0.234\ O_{3\,avr} + 0.086\ RH_{mean} - 12.32, \quad (2)$$

Table 1. Regression analyses for pollutants' average concentration in Mississauga.

Dependent Variable: O_3_MIS_AVR				Dependent Variable: PM_MIS_AVR			
Model	**Coef.**	***t***	***p*-Value**	**Model**	**Coef.**	***t***	***p*-Value**
(Intercept)	32.411	26.356	<0.001	(Intercept)	−12.320	−16.104	<0.001
RH_avr	−0.255	−17.294	<0.001	RH_avr	0.086	9.826	<0.001
PM_Mis_avr	0.736	19.004	<0.001	O_3_Mis_avr	0.234	19.004	<0.001
Mean Temp	0.338	7.670	<0.001	Mean Temp	0.429	18.584	<0.001

The above equations were used to predict the average concentrations of the pollutants in Mississauga. The predictive regression was conducted for two months (August and September 2016) covering two periods of heat warnings (4 August to 13 and 6 September to 8). Figures 2 and 3 show the predictions of O_3 and $PM_{2.5}$ mean concentrations against the daily mean temperature. The inclination of the linear predicted regression lines confirms the significant correlation between the mean temperature and the pollutants' mean concentrations. The figures show that the highest values for the O_3 and $PM_{2.5}$ mean concentrations were recorded during the August heatwave. Moreover, the peaks of the graph behavior for both pollutants followed the behavior of the mean temperature, which ensures the correlation between air quality and hot ambient conditions.

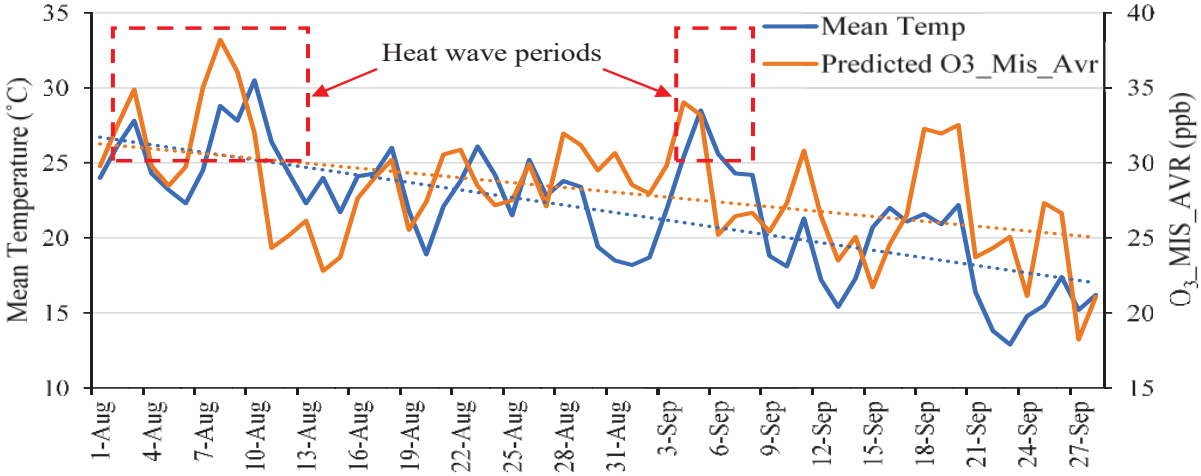


Figure 2. Predictions of O_3 mean concentration in Mississauga in relation with mean temperature.

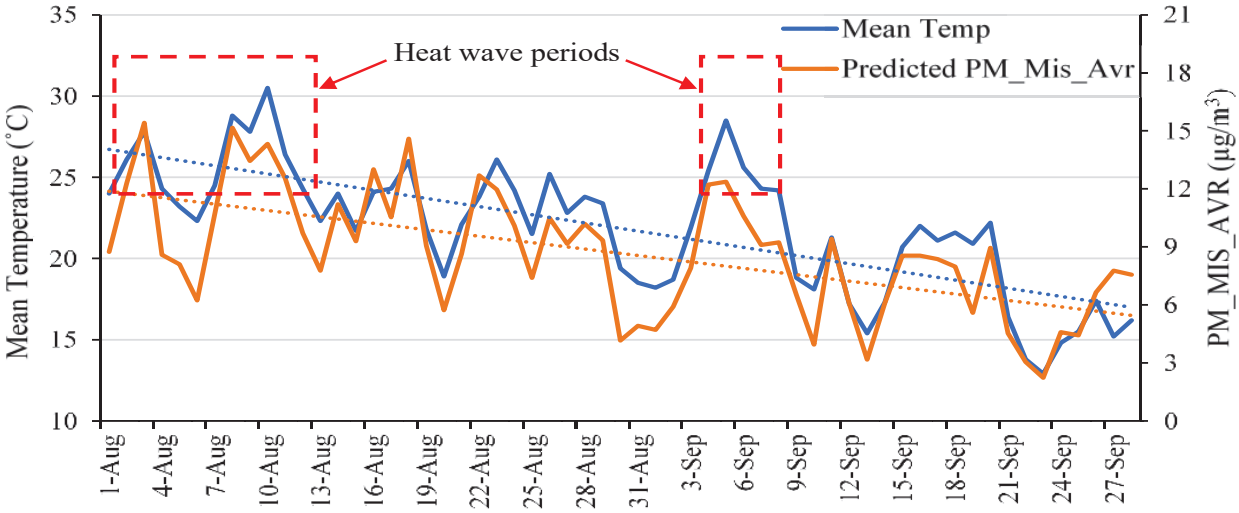


Figure 3. Predictions of $PM_{2.5}$ mean concentration in Mississauga in relation with mean temperature.

The regression analysis of the mean concentrations of both pollutants in Brampton is presented in Table 2. Comparing the results with those of the municipality of Mississauga, it is confirmed that the correlations and the effective variables are identical in both municipalities. As reported in Mississauga, the correlation is more significant between the mean temperature and the $PM_{2.5}$ mean concentrations. Overall, the predictive regression results are close to the predictive regression equations for Mississauga, which can be verified to predict pollutants' mean concentrations in the GTA.

Table 2. Regression analyses for pollutants' average concentration in Brampton.

Dependent Variable: O_3_BRM_AVR				Dependent Variable: PM_BRM_AVR			
Model	**Coef.**	***t***	***p*-Value**	**Model**	**Coef.**	***t***	***p*-Value**
(Intercept)	34.036	28.474	<0.001	(Intercept)	−13.298	−16.604	<0.001
RH_avr	−0.285	−19.842	<0.001	RH_avr	0.111	12.133	<0.001
PM_Mis_avr	0.724	19.911	<0.001	O_3_Mis_avr	0.257	19.911	<0.001
Mean Temp	0.518	12.561	<0.001	Mean Temp	0.310	12.637	<0.001

4. Effect of Increasing Urban Greenery Cover

The cooling effect of the urban greenery cover is due to the fraction of the blocked solar radiation that reaches the urban surfaces [11,12] and the evapotranspiration of plants and soil of the vegetation and tree coverage [19]. However, the increased humidity levels due to evaporation can affect thermal comfort, causing a counter warming effect. Most of the reviewed studies utilized numerical simulations to predict the effect of increasing the greenery cover [11,13,20]; however, the prediction of the warming effect and increased relative humidity due to the evaporation of the increased green cover is limitedly discussed. Additionally, a more accurate representation of the energy and mass balance for the urban air volume is required. This ensures the importance of developing a simulation tool that efficiently estimates the cooling effect of the green cover while considering the sequences of the warming effect on the urban climate.

The microclimate simulations were designed utilizing the developed and validated version of the UWG [15] to evaluate the current natural surroundings within the proposed neighborhood and to assess the effects of increasing the green and vegetation cover on the urban thermal behavior and building energy performance. Specifically, the study investigated the effects of preserving and developing the natural content of the river valleys region in Brampton, ON. A typical urban typology adjacent to a river valley was selected

representing the Brampton residential neighborhood. The weather data for Guelph town, ON. was used as the rural weather station for simulation. The verification of the selection of the rural site, comparisons with nearby rural locations, and full characteristics of the rural site were provided by Dardir and Berardi [15]. The simulation was extended for 10 days (from 27 June to 6 July 2018) to include the reported heatwave (from 29 June to 5 July 2018) during this period. Details of location, urban features, and assumptions are provided in Table 3.

Table 3. Specifications of the urban microclimate parameters.

Location	Brampton, ON
Distance from rural	35.5 km
Site area	528,000 m^2
Building footprint	24.6% (130,000 m^2)
Avr. building height	6 m
V-to-H [1] ratio	0.25
Road urban area	33.5% (133,500 m^2)
Water surface area	5.7% (22,500 m^2)
Tree canopy	20%
Vegetation cover	60%
Building types	100% residential

[1] Vertical to horizontal aspect ratio for urban canyon.

The study mainly focused on air temperature and relative humidity as simulation outputs; it also monitored the energy consumption of the buildings. To assess the effects of increasing the greenery cover on the local urban climate of the Brampton neighborhood, three levels of the investigation were designed: increasing the tree canopy from an initial value of 20% of the urban area by 10% for three steps, integrating vertical vegetation façade systems that increase by 20% of the building façade area for three steps associated with largest tree coverage, and proposing green roofs coverage that increases by 20% of the building roof area for three steps associated with the maximum tree canopy and the vegetated façade system. As the urban area is limited by roads area and urban features, the tree canopy was selected to have a maximum possible coverage of 50% of the urban area. However, with an increased possibility to implement green roofs and vegetated façade systems, the maximum possible coverage was set to 60% of the building area. The stepped investigation was planned to evaluate the most effective mitigation strategy for reducing the ambient air temperature and building energy consumption. The green roofs involve integrated vegetated areas and plantation to building roofs which provide both insulation and shading; both effects were included in the developed version of the UWG. The results of the mitigation scenarios were compared with the current condition that was considered as a reference case. The reference conditions present 20% urban tree canopy, 0% green façade systems, and 0% green roof installations. All the results of the proposed scenarios for all strategies are presented in Table 4.

Referring to the comparisons between the reference case and the scenario of maximum enhancements (50% of the tree canopy, 60% of green façade coverage, and 60% of green roofs), it was inferred that the 10-day average air temperature was reduced by 2 °C. Regarding the energy consumption of the buildings, applying the enhanced scenario saved an amount of 1.55 kWh/m^2 of energy consumption, which represents 25.6% of the energy consumption during 10 days of operation. Regarding the warming effect of the increased green cover, the increased relative humidity was tracked. The scenario with maximum enhancements achieved an increase of 7.2% of the 10-day average RH more than the reference case. To justify the effect of this increase on the thermal environment, the outdoor heat stress index was used to assess outdoor thermal resilience. It was expressed by the Canadian temperature–humidity index (*Humidex*). Humidex values were calculated based

on the ambient air temperature (T_a) and dew point temperature (T_d) [21,22], as shown in Equation (3).

$$Humidex = T_a + 0.5555 \times (6.11 \times e\hat{}(5417.753 \times (1/273.15 - 1/(273.15 + T_d))) - 10), \quad (3)$$

Humidex values were assessed for the whole simulation duration and are presented in Figure 4. The results show a reduction in the 10-day average Humidex from 27.6 to 25.7. During the heatwave period, the maximum Humidex value was reduced from 41.2 to 37.6. According to Health Canada [22], heat warnings are issued when the Humidex value exceeds 40, which was achieved during the heatwave applying the reference application. With the enhanced scenario application, the overall outdoor thermal performance was enhanced, and the condition of the heat warning was not met during the heatwave, keeping the neighborhood away from heat stress dangers. This ensures the effectiveness of the mitigation strategies in controlling extreme weather conditions, promoting climate resilience to the neighborhood population.

Table 4. Ten-day average values for the simulation parameters.

		Air Temp (°C)	RH (%)	E (kWh/m^2)
Reference case		22.19	71.88	6.05
Increasing tree canopy	30%	21.95	72.76	5.84
	40%	21.74	73.6	5.74
	50%	21.5	74.45	5.68
Increasing green façade system [1]	20%	21.37	74.98	5.36
	40%	21.22	75.53	5.14
	60%	21.07	76.09	4.77
Increasing green roofs [2]	20%	20.76	77.2	4.66
	40%	20.47	78.17	4.57
	60%	20.2	79.06	4.5

[1] Applying 50% of tree canopy. [2] Applying 50% of the tree canopy, and 60% of green façade coverage.

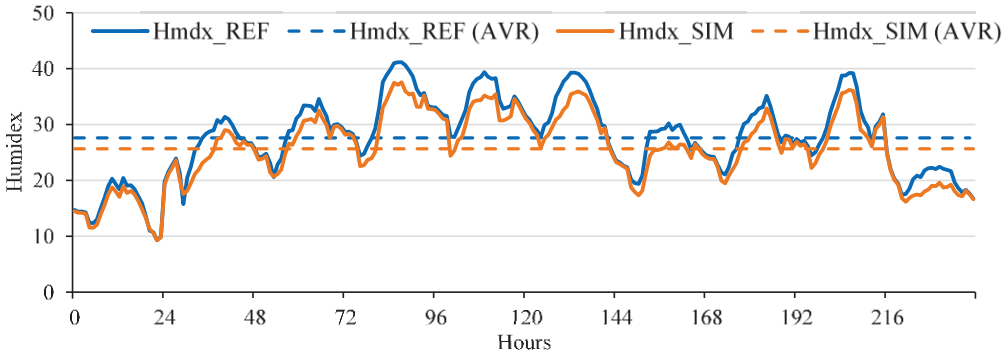


Figure 4. Humidex values of reference case and enhanced urban microclimate (from 27 June to 6 July 2018).

Regarding assessing the individual impact of the mitigation strategies, performance analysis was conducted for the proposed strategies on the air temperature and energy consumption for each step during the simulation. It is worth mentioning that while the value of each strategy was changed, the other strategies were constant. Figure 5a shows how far the mitigation strategies contribute to the evolution of canyon air temperature. As noticed, the tree canopy was the most effective strategy for reducing the canyon air temperature with a reduction of 0.23 °C for each 10% increase in the tree canopy, as derived from graph slope. Meanwhile, reductions of 0.08 °C and 0.14 °C were associated with each 10% increase in the green façade system and green roofs, respectively. Referring to Figure 5b, it can be concluded that the green façade systems were the biggest contributors

to the building energy savings with an amount of 0.15 kWh/m^2 for each 10% increase in façade vegetation. Moreover, each increase of 10% in the tree canopy and green roofs contributed to the building energy savings by 0.08 kWh/m^2 and 0.04 kWh/m^2, respectively.

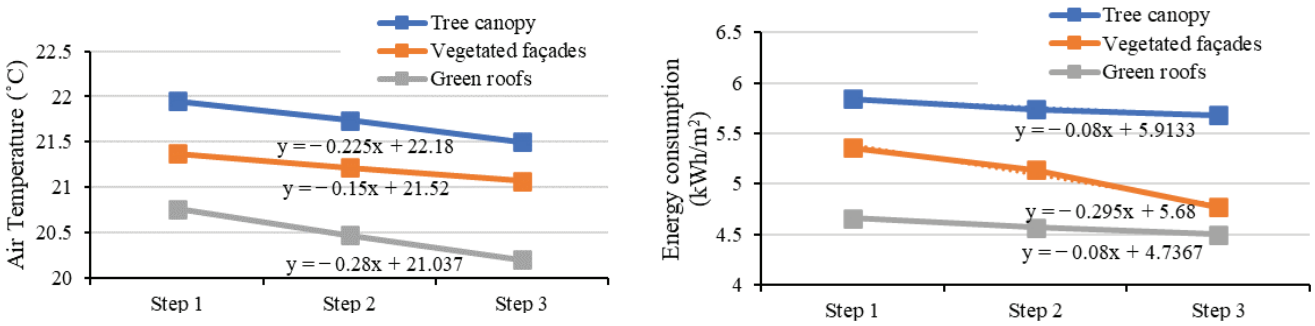


Figure 5. Effect of mitigation strategies on (**a**) canyon air temperature and (**b**) building energy consumption.

5. Health and Economic Responses

In this section, the linkage among ambient thermal conditions, air pollutants levels, population health response, and possible economic savings is approached. Based on statistics Canada [23] and Region of Peel [24], the annual all-cause mortality cases in Mississauga and Brampton are expected to reach 3530 and 3290 persons in 2030, respectively. Regarding the heat-related health response of the population, based on the correlations between all-cause mortalities and ambient temperature conducted by Anderson and Bell [25], an increase in mortality cases of 4.5% was estimated for each degree Celsius increase in ambient temperature. Using this estimation, the annual all-cause mortality cases are expected to increase by 159 and 148 persons in Mississauga and Brampton, respectively, for each degree Celsius increase in ambient temperature. Referring to the simulation results of the maximum enhancements of the urban microclimate, it can be inferred that, by increasing the urban greenery cover, the ambient air temperature was reduced by up to 2 °C. Thus, applying the rate that relates the mortality cases to ambient temperature, the reduction in all-cause mortalities in 2030 is expected to reach 311 and 290 persons in Mississauga and Brampton, respectively. This reduction in the total mortalities is estimated as 8.8% in both Mississauga and Brampton. Additionally, the reduction in ambient temperature is associated with improving the air quality levels, as indicated by the regression analyses. Based on the predictive regression and simulation results, the O_3 and $PM_{2.5}$ daily mean concentrations are expected to decrease by 0.68 ppb and 0.86 μg/m^3, respectively, on average. These rates were considered to be applied to the municipality level, assuming the same enhancement procedure will be conducted for all the districts.

The economic benefits associated with reducing ambient air temperature were discussed by Wilson [26], applying the case study of Brampton. Avoiding exposure to extreme heat can save the total related losses by up to 45%. The related economic benefits include reducing the health system costs that involve the cost of hospitalization, increased emergency department visits, and ambulance calls due to heat exposure. They also include reducing the productivity losses attributed to increased breaks for outdoor workers due to heat exposure. Referring to the simulation results, the enhancements of the urban microclimate ensured that the neighborhood would not meet the conditions of heat warnings. Accordingly, applying the enhancement procedure for the GTA can maximize the economic benefits by higher potential savings of health and labor systems losses, solving many climate stress issues witin the GTA [4].

6. Conclusions

An integrated statistical–simulation approach was designed to figure out the influences of the adaptation of urban greenery cover on air quality and community responses. A newer version of the Urban Weather Generator (UWG) was used to assess the UHI mitigation strategies, including increasing the tree canopy (from 20% to 50%), integrating vertical vegetation façade systems (up to 60%), and incorporating moderate-to-intense green roofs (up to 60%). The results proved that the tree canopy and the green façade systems were the most effective strategies for reducing the canyon air temperature and building energy savings, respectively. Regarding building energy consumption, applying the enhanced scenario achieved energy savings of 25.6% of the energy consumption during 10 days of operation. Moreover, a statistical-based model was designed to find the correlations between the meteorological parameters and the air quality variables. The statistical approach included regression analyses for establishing correlations to assess the impact of meteorological variations on air pollutants concentrations. The results confirmed a significant positive correlation between O_3 and $PM_{2.5}$ concentrations and ambient temperatures. It was concluded that for every degree Celsius increase in the mean temperature, the O_3 and $PM_{2.5}$ mean concentrations were expected to increase by 0.34 ppb and 0.43 $\mu g/m^3$ on average, respectively. Additionally, the paper approached the linkage to health and economic responses. Applying the heat-related health response within the region of study, reductions of 8.8% in all-cause mortalities were expected in the region of study in 2030. Additionally, potential savings of health and labor system losses were expected due to protecting the urban environment from extreme heat exposure. The integrated approach developed in this paper can be used by decision-makers to predict the appropriate urban greenery cover that maximizes the environmental, health, and economic benefits. Thus, specific policies can be initiated to improve living conditions for urban dwellers.

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Conflicts of Interest: The authors declare no conflict of interest.

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environmental sciences proceedings

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Proceeding Paper

Sustainable Urban Development in Vast Patagonia to Address Socio-Ecological Relationships and Climate Change: A Case Study of a Mixed Coastal Urbanization Project †

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Abstract: As the population grows, the deteriorating quality of ecosystems and the increased area of urban environment are correlated affected by climate change and affecting public health. It becomes critical to reach a balance between demographics and the natural environment to reduce pressure on our ecosystems. Creating improved conditions for sustainable urbanization is vital for supplying greater protection of biodiversity and people. This semi-urban project development represents a possible scalable model of sustainable development in an arid coastal environment. It is aligned with the sustainable development goals (SDGs) and country NDCs (National Determined Contributions) towards the reduction of emissions and mitigating climate change. It aims to support socio-ecological relationships and energy transitions towards low emissions and economic, ecological, resilient, and inclusive urbanizations. More than one hundred landfills, dune erosion, and their impacts on a coastal environment are some of the issues related to human behavior identified through observation in the project site. Viable solutions that were researched include landfill sanitation, landscape regeneration sustainability, and accessibility.

Keywords: sustainable urbanization; arid environments; eco-urbanization; mixed urbanization; Patagonia; urban planning; eroded coastal; energy transitions; dune; coastal regeneration

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1. Background—Human Footprint

Climate change and its present and future impacts—including the spread of infectious diseases and pandemics—have direct consequences. Climate change as a result of continuous carbon emissions represents a serious risk to communities with irreversible consequences if mitigation measures are not implemented within a short timeframe [1]. The implementation of a climate risk finance management program provides an integrated framework allowing sustainable economic development [2]. Argentina has adhered to the Paris Agreement where compliance with emission reduction goals requires significant investments. However, access to finance programs is essential to achieve implementation and long-term recovery. In addition, recent pandemics have added a sanitary challenge highlighting the need for investments in green recovery, favoring coastal ecological systems and energy transitions [3]. the contribution of the private sector in cities is perceived to be beneficial in the implementation of mitigation actions to reach the country (NDCs) [4].

2. Introduction—Project Description

The location of the project is in the eastern Atlantic on the Patagonia coast, at latitude 45° south, in the province of Chubut, Argentina (Figure 1). It is a mixed urbanization based on pillars of innovation, sustainability, accessibility, integrating residential areas, landscape reserves, and areas intended for the public community. The urban masterplan contemplates the geomorphological characteristics of the terrain and the surrounding nature.

Figure 1. Location in Patagonia at latitude 45° south, 1800 km south of Buenos Aires.

The long-term goal is to improve the quality of life of the Patagonian inhabitants in a context in which sustainability is paramount and respects the natural environment. The efficient use of energy with its own generation of renewable energy is prioritized in residential areas, along with waste and water management strategies. The concept of ecological urbanization is supported by bioclimatic architecture, designed to take advantage of the location of the sun, shadows at this latitude, and thermal insulation materials to maximize energy efficiency.

The proposal in the public area combines free and improved access to the beach, parking, and services such as a scientific research center, Patagonian sports club, and ecotourism, among others.

The combined approach is implemented in a natural and orderly environment available to the entire community. It is organized in an urban framework, where the neighbors assume commitments such as the use of renewable energies, the recycling of waste, among others, and respecting and valuing the surrounding ecosystems. The objective is to offer collective and inclusive solutions. To ensure the success of these initiatives, a team of specialists in each discipline provides support and guidance to residential users. The project aims to provide specific solutions to the following local and regional issues:

- Demographic and concentrated growth with its back to the sea.
- Poor environmental awareness related to coastal erosion.
- Negative effects of human misuse on coastal dunes, generating erosion and landfills.
- Housing shortage in a context of lack of appreciation of the sea and nature.
- Scarcity of drinking water resources in arid Patagonia.
- High dependence on fossil fuels in electricity generation.
- Low thermal efficiency in buildings resulting in higher energy consumption.
- Lack of policies to achieve sustainable development and climate mitigation actions.

The solutions proposed for overcoming these challenges are described below.

3. Demographic Growth and Sustainable Development

The Patagonian nearby coastal city has its origins in the early 1900s with the greatest demographic explosion attributed to the discovery of oil. Thousands of workers arrived seeking opportunities following great economic growth. Communities by then were organized in oil camps, which resulted in concentrated neighborhoods, often suffering from poor connectivity and long-term urban planning, with their backs to the sea and natural beauties [5]. The current urban proposal represents a low density of housing in a

context of coastal nature, where urban order is organized in residential, landscape reserves and new public areas.

4. Urban Planning—Density and Connectivity

The project is developed in a peri-urban area, incorporating novel concepts in relation to the Patagonian landscape. The coastal land was subjected to decades of soil extraction from a former quarry and misuse by human action (Figure 2a,b), therefore, the masterplan was adapted to the existing geomorphology of the land highlighting the beauty of the place. The low-density neighborhood proposal focused on people and the ecology. The urban design proposes a low density of land occupation, where more than 70% is dedicated to landscape reserves, community, and service areas. In addition, urban parameters such as the SOA are only 25%, which is defined as the portion of land occupation in each terrain parcel. Combining these parameters, it means that only 10% of the total land is covered by construction, thus enhancing the natural landscape.

(**a**) (**b**)

Figure 2. (**a**) Coastal terrain before restoration, revealing a severe erosion. (**b**) Simulated long term coastal profile, and sand dunes restoration.

The design of common buildings includes bioclimatic construction, which incorporates factors relative to the latitude, such as the position of the sun, wind, and other constituent elements of the environment. Innovations in thermal insulating materials and the generation of renewable energies are favored, to support energy transitions. Other strategies to mimic houses to the environment include green roofs with vegetation. Internet of Things (IoT) connectivity and smart city technologies for the administration of public services, control of energy generation, an onsite treatment of sewage. All these combined solutions are unknown in the region.

The proposal is aligned with the 15 of the 17 United Nations objectives of sustainable development, objectives, 1, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15, 17. With a special focus on objective 11 sustainable cities and communities.

There are incentives for the use of residential renewable energies with subsequent reinjection into the electricity grid supported by the new law for the Promotion of Distributed Generation of Renewable Energy Integrated to the Public Electricity Grid [6].

The urban plan design favors pedestrian and cycling mobility where all necessary requirements for life will be located within 10 min. In the future, dedicated parking areas with solar chargers for electric cars and scooters will be installed in favor of energy transitions.

Regeneration and Climate change mitigation proposal:

- Energy: distributed generation residential renewable energy, energy efficiency in buildings.
- Rewilding and ecological restoration of degraded environments.

- Circular economies.
- Mobility: urban planning to facilitate walking, cycling, and solar chargers for electric vehicles.

5. Regeneration Strategies

5.1. Ecological Reserve Donation

Motivated by constant aggression by hunters of the fauna, the founder of this project and owner of the adjacent land that hosts a colony of sea lions decided in the year 1985, to donate this part of the land for conservation of ecology. This allowed tourist development. The area was later converted into the Protected Natural Area Punta Marques, controlled by the government of the province.

The project contains a key component in regeneration and conservation, with related initiatives in this direction.

5.2. Dune Coastal Regeneration

Urban development is planned in harmony with the topography, to ensure the sustainability of the coastal systems, and establish ecological corridors. Otherwise, the coastal cities will risk climate consequences, such as flooding, heavy storms, loss of biodiversity and sea-level rise. Therefore, sustainable planning principles had to be implemented in the coastal cities to diminish the effects of the natural risks [7,8].

The adjoining coastal sector of Belvedere Beach was affected by human misuse for decades. The area was subject to solids exploitation and motorcycle tracks, causing the compaction of the sand and the destruction of native vegetation that was very sensitive and slow-growing. It was subject to vegetation fires and waste disposal. The presence of waste on the beach and high volumes of plastic that ended up in the sea is just one of the coastal environmental issues (Figure 3). Plastics in the ocean are of ecological concern worldwide, because in this environment they take hundreds of years to degrade and affect marine fauna [9].

Figure 3. Complicated environmental situation after recreational activities and garbage generation. Plastics in the ocean are one of the main ecological concerns worldwide.

The coastal erosion of the resulting dune system has a strong impact on this type of environment and is visualized with the retreat of the coastline and the decrease in the volume of sand on the beach.

To restore a similar level of protection, mitigation measures must be taken to regenerate and then preserve the coastal environment and ecosystem. These environments are very sensitive to erosion due to the poor structure of the soils exposed to wind and water erosion [10].

After researching several hard and soft mechanisms of coastal protection, a bioengineering solution was selected. The objective of this approach—never implemented on a Patagonian Atlantic beach—was the reestablishment of the dune system providing coastal protection (Figure 4). Once in place, this system will behave dynamically, with the action of the sea and predominant wind.

Figure 4. Partial rebuilding work of coastal dunes and elevation of coastal terrain.

The sand material used for the regeneration of the dunes was sourced from the soil in the lagoon sector, so was totally compatible with local sand. This is considered of regional interest and a unique experience on the southeast Atlantic coast of Argentina. It serves as a restoration project providing positive environmental impacts.

Regeneration of sand dunes has the following main objectives:

- Secure the availability of sand for a dynamic coastal process by wind and marine action.
- Provide long-term protection, extending the berm and dry beach to aid against extreme weather and climate effects. It also recreates an additional section of dry beach for recreation purposes for the public beach during the summer (Figure 5).

Figure 5. A section of dry beach following partial restoration work and regenerated by a dynamic coastal process of wind and sea action. This section is available for public recreation purposes during the summer.

The huge value that sand-dunes have, in terms of shoreline coastal protection, are extensively recognized as several countries have tackled the erosion problem by rebuilding and preserving dunes. This is a technical solution effort that blends natural landscape and environmental enhancement by using compatible local sand.

5.3. Revegetation

After recovering a decayed ecosystem, it is essential to prevent it being re-exposed to the same factors and human behavior. Therefore, once rewilded with native species, the coastal section will be assigned to a landscape and coastal reserve for future preservation.

Concerning vegetation, it is proposed to maintain the physiognomic-floristic attributes of the dominant plant communities [11]. Reimplantation of native species is a slow evolution process. However, it is reinforced by seedling natural regeneration, top-soil technique, and transportation of seeds by wind over time. Once the dune system has been regenerated and stabilized by native species, the plants need to be preserved, as they are responsible for the formation and maintenance of coastal dunes.

5.4. Coastal Reserves

Coastal dunes are one of the most biodiverse ecosystems in Patagonia, providing important ecosystem services to society. Yet, they are also one of the most threatened. Biodiversity loss is taking place at a high rate, which is a growing concern from the perspective of ecosystem functioning. Dune restoration in Bevedere beach could help prevent biodiversity loss while improving citizen wellbeing.

The objective centered in restoration is to promote the conservation of the coast, respect for the environment to combat climate change. The creation of a coastal bio-corridor that allows species to move, even in a semi-urban environment, with the role of conservation and preservation of coastal space, vegetation, birds, and other fauna. Implementation and control require a technical team for care through a management plan [12].

It highlights the ecological purpose the private sector is giving to restore nature in a coastline currently eroded by decades of human degradation.

The proposal:

- Restoration: dune environment and reforestation.
- Conservation—management program.
- Monitoring of the main groups of terrestrial species: vegetation, birds, reptiles, insects, and mammals.
- Monitoring of intertidal biodiversity and marine fauna.
- Fauna observation points and centers.

Other programs:

- Guided visits to raise awareness of the richness of coastal biodiversity.
- Visitor information center.
- Scientific research center and interpretation center.
- Environmental education programs.
- Beach certified program (access and mobility, visitor information, parking, recycled waste center, lifeguard space).

5.5. Beach Quality Certification

The project promotes a beach management program jointly with local authorities to bring the beach to acceptable public conditions for accessibility, sanitation, and safety. This will be achieved by implementing a beach certification program with the objective of connecting the public with nature and encouraging them to learn more about their environment.

For this purpose, environmental education activities are offered and promoted, as well as a permanent exhibition of information pertinent to the place with regards to biodiversity, ecosystems, and environmental phenomena. Adherence and compliance to the program require meeting educational, security, and accessibility criteria for approval at international level.

5.6. Nature of the Restoration and Reserve Management

As for the negative effects of human frequentation, they are resolved through management systems, beach access points, assigned scenic trails, elimination of vehicular traffic on

the dunes, and educational signs. The information to the citizen contributes to the purpose of protection and recovery of this coastal area, creating awareness about dune preservation.

The subsequent elimination and prevention of garbage dumps in the coastal sector will produce an improvement in the quality of the terrestrial and marine environment. Therefore, the sanitation and regeneration of the dunes as a reserve will mean the landscape will be positively affected, improving the quality of ecosystems and life for citizens who visit the beach.

Conservation management actions are important, after the elimination or reduction of the causes that have produced the alteration of the dune system (extraction, human traffic, vehicular traffic, garbage dumps). This is the most feasible action to guarantee success avoiding the previous situation of degradation.

6. Circular Economies

Global society faces an unprecedented socio-ecosystem crisis. This is partly due to the current development model based on a linear thinking economy that extracts, transforms, consumes, and discards finite resources that often, cannot be reinserted into natural cycles, reducing the management and conservation of natural goods and services [13].

The sustainable urban initiative follows a triple impact motivation with related actions contributing to communities improving their social, economic, and environmental protection.

It promotes changing linear consumption habits, in which production, follows consumption and finally disposal, to circular and responsible consumption, migrating to "use and recycle", where waste becomes a resource and returns to the value chain. The project coastal site is plagued with plastic, generated by recreational activities on the beach that could be reused and recycled. Regeneration of the resource helps organizations that surround these initiatives promote local economies, circularly generating business and activities, a model that is giving value to the entire chain of consumption.

New generations are more aware of the environment and decisions in the sustainability of products, traceability production and its practices. Implementation requires responsibility and commitment from all actors involved, especially residential users and temporary users of public areas. A clean beach certification program supports the recycling initiative with educational programs and dedicated differential waste separation in place.

7. Water Recycling

Water scarcity is the greatest challenge we face today in these arid regions and globally. The starting point is to put a proper value on water by recognizing that it is a precious resource that needs to be better managed, valued and preserved. One solution is to use water more efficiently by installing water meters, however, understanding and tackling water scarcity effectively requires other wide-ranging measures. The challenge is also making the water supply more resilient, reducing difficulties in access to water in arid zones by integrating water, sanitation with water resources, and waste management.

Across these areas, technology has a pivotal role to play in the home, or water distribution systems.

Water solutions in this urbanization project consider a biological sewage treatment system for using treated water for irrigation in boulevards for enhanced water efficiency. Biosystems are semi-closed systems that work in a decentralized and circular way, promoting energy autonomy, access to water and waste management of community spaces, thus strengthening their resilience.

On the potable water supply, being coastal urbanization, it is contemplated that a desalination plant at pilot scale will be needed for contributing once more to the sustainable development goals.

8. Environmental Education and Workshops

A series of workshops will be scheduled for community participation to transfer knowledge and skills to the local community on themes of sustainable urban development.

Sessions on specialty themes with invitees from specialists, academia, and suppliers to accelerate the reduction of emissions on topics of coastal conservation, renewable energy, water management, recycling/circular economy, mobility, green heating, and IoT/smart city.

9. Replicability

This project can be partially or totally replicated as a model of sustainable development. It expresses the means to address population growth in Patagonia with a novel urban approach, in terrains of land compatible with urban use outside dense city conglomerations. It intends to reduce urban density, preserving the natural aspects of the land, and restoring it when it is damaged. It considers a specific urban plan design adapted to the geomorphology of the terrain with a bioclimatic strategy with architecture suited to the environmental elements such as weather, sun, and latitude.

This model allows the use of land to offer services to communities for human development, either ecological, residential, recreational, education, scientific, or a combination.

10. Local Ownership—Beneficiaries

The direct beneficiaries are new residents that share the vision of sustainable urbanization in complete integration with the surrounding nature. Other beneficiaries are visitors and tourists who will enjoy access to the beach in proper conditions of hygiene, safety, and environmental balance in terms of a public good, in contrast to its current deteriorated conditions. Indirect beneficiaries are groups of communities that will access onsite facilities and be assigned infrastructure for research, sports, and education. The scientific community will access facilities to perform specific studies on topics of algae, microalgae, bivalves, and biodiversity. Additionally, local organizations will benefit by collecting recycled materials, to reinsert transformed goods into the economy.

11. Conclusions

This sustainable mixed urban development project addresses a small-scale topics of coastal restoration, clean energy, waste, and water management with a consequent positive impact on climate change mitigation. It allows replication and scalability and, therefore, the opportunity with a small contribution of generating a positive global impact. The project offers capacity building to support energy transitions towards low emissions, ecological, resilient, and inclusive communities.

It is essential to incorporate country finance programs to tackle climate risk mitigation, as ignoring today's issues will exacerbate conditions for further deterioration of economies and people's wellbeing.

As seen by a correlation between urban environment and health, the quality of ecosystems and urban environment impacts hygiene and public health. Ultimately, reaching a balance between demographics and the natural environment improves conditions of sustainable urbanizations and greater protection of biodiversity.

Regeneration of dunes with compatible sand was considered of high interest and a unique experience in the southeast Atlantic coastline of Argentina. Rewilding native species supports the creation of biodiversity corridors for an ecological reserve that favors the development of life. Besides biodiversity conservation, the impact of sand dune lies also in the provision of ecosystem services, related to recreation and ecological education. The role of ecosystem services and ecological restoration of eroded land provides significant positive conservational and wellbeing outcomes.

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Proceeding Paper

Gender Agenda for Climate Adaptation: A Pact for Governing Adversity †

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Abstract: What is proposed is the construction of a gender agenda in the implementation of climate adaptation projects for Latin America, whose fundamental characteristic is the consideration of a double transversalization between gender equality and adaptation to climate change. To this end, a case analysis is used for the main climate adaptation initiatives in the region, with the objective of constructing our proposal from that implied by public policies and, above all, the socio-cultural norms and exclusions existing in the region.

Keywords: gender; climate change; climate adaptation; gender agenda; Latin American region

1. Introduction

Today, the effects of climate change are undeniable, because in addition to generating a higher level of uncertainty towards the future, they have led to an increase in social imbalances that currently generate high levels of inequality expressed in different facets such as inequality by income, territorial distribution, gender, and inequality in the perception of the impacts of climate change. Although they have reached everyone, there are some groups that have resented them to a greater extent, given their historical level of vulnerability in economic, cultural, social and political terms; those with the levels of greatest vulnerability are women, and as such, they are accentuated victims of the negative effects of climate change. The importance of understanding the lack of neutrality in this problem dictated by gender is found in the formulation of actions for mitigation and adaptation of climate effects, since by remaining biased from this perspective, the results of their development would not only imply a limitation of benefits in terms of climate, but also on a social scale, since they foresee a widening of gender gaps guided by this historical vulnerability.

What this research proposes is the construction of a gender agenda in the implementation of climate adaptation projects for Latin America, whose fundamental characteristic is the consideration of a double transversalization that allows the dimensions of gender and adaptation to climate change to be considered at all levels of development in the region as an imperative of this double problem that plagues more than half of the Latin American population. Finding a common characteristic of abandonment from the gender perspective, we built our proposal focused on seven priority elements identified in the case studies, such as: decision-making spaces in climate change; food security; access to means of agricultural production; natural disasters; access to social support; migration; digitalization and access to Information and Communication Technologies (ICT); as well as access to financing. This initiative is formulated in a full transversalization from that involving public policies and above all socio-cultural norms and existing exclusions in the region.

The contribution concludes that climate change adaptation interventions should be based on an analysis of the conditions of gender inequality in the region and other indicators that characterize it multidimensionally, which will make it possible to differentiate needs and capacities by gender, and thus abandon the stereotypes that persist in the sector.

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2. A Double Inequity

The current situation in Latin America is clear evidence that all problems at a generalized level are constituted as a cause and consequence of the differentiated effects that affect society, as in the case of those generated by climate change and that affect women to a greater extent.

The phenomenon of double inequity, which is represented as a sequence of inequalities, has been explained theoretically by two fundamental factors. The first of which is biological, and falls directly on those determined by sex, such as the comorbidities that make women more vulnerable to the effects of climate change, and sociocultural factors, which include everything related to gender, such as the biases and exclusions experienced in the social structure, simply due to being women [1].

In such a way that vulnerability becomes a limiting predisposition of the capacity and resilience to recover or adapt to the conditions of environmental degradation and natural disasters, according to a study by [2] it was found that women suffer a greater impact than men in extreme weather events. In the selected sample of natural disasters that occurred in Latin America, it was evidenced that when women's economic and social rights are unprotected, they are 14 times more likely to die; a phenomenon that does not occur in countries where all people without exclusion of sex and/or gender enjoy rights and their mortality is lower [3]. In the case of Latin America, this figure is increasing by a rate of 1.6 per 100,000 women due to climate change [4], as a consequence of the limitations that the unequal socioeconomic status of women has generated, and their low adaptation to risk. It is necessary to mention that 70% of poor people in the region are women, and their vulnerability is accentuated according to their race, ethnic group, and age. Such is the case of urban households headed by women of which 40% are in conditions of poverty, making it difficult for them to relocate to protect themselves from the negative effects of climate change. In the rural sector, women are the main group involved in the production of staple foods with 65% participation and ownership of approximately 10% of the total arable land and animal production, meaning that the profits from their work are not reflected in the increase in their incomes. This means that the profits from their work are not reflected in an increase in their income, but rather in an activity that complements the activities of male landowners. It must be remembered that agricultural activities have been particularly affected by droughts and floods caused by climate change, which in turn has caused women who work in these activities to lose their main source of income and have greater difficulty adapting to the effects of climate change by losing their source of income, food, and not having the ability to adapt to a new activity given the urgency of their needs [5]. As such, a labyrinth is constructed between the causes and consequences of the double inequity in climate change. Among a representative list of these effects, we list the following.

For women and girls in the region, the water supply problems generated by climate change have caused them to triple the number of hours they devote to fetching and transporting water and firewood for their families. Likewise, it is necessary to consider that even with this increased use of their time in these activities, more than 40% are in a condition of scarcity of these means. That is, around the world, the average time spent by each family in transporting water and firewood for domestic activities is 1320 h per year of which 1095 h are spent by the women in each family, limiting them from other activities necessary for their full development such as education, recreation. and rest [6]. This generated a reduction in children's time in schools because of the fulfillment of women's role in family reproduction, as well as migration associated with the effects of climate change, or the need to move for medical assistance in shelters and humanitarian assistance facilities, although these alternatives still represent a limited option due to economic constraints, the overload of care responsibilities, and work [7].

Likewise, among other responsibilities of women, the provision of water, food, and firewood, women are responsible for food cleaning and waste disposal, so they are strategic allies in preventing the spread of endemic diseases. At the same time, it implies an overload in the intensity of women's unpaid (and paid) work, and in the same way, it increases

the risks to their health [8]. In relation to the above, we find that women are exposed to greater amounts of POPs (e.g., pesticides, household cleaning products, etc.), and that women are exposed to greater amounts of pesticides (e.g., pesticides, household cleaning products, etc.). With a thicker subcutaneous fat layer that retains POPs and other residues of toxic chemicals, the health effects of environmental hazards have a greater effect on women [9], such as vulnerability to malnutrition, infectious and respiratory diseases of pregnant women, increased risks of maternal mortality, unwanted pregnancies, and even in malaria and COVID-19 infested areas infected pregnant women are at risk of contracting anemia or having other health complications that can be life-threatening, which becomes a worrisome condition knowing the figures regarding access to medical services for women in the region. Finally, in terms of health, women are at greater risk of contracting Zika, malaria, and dengue fever, as well as other injuries due to heat waves and fires caused by climate change.

Finally, it is also estimated that the effects on labor productivity, due to the low response or recovery of women and their high vulnerability, have seriously affected their capacity to manage natural resources and their way of life, their means of production, food security, and well-being. In addition, women perform a large number of activities that are not valued or remunerated, such as care, domestic activities, and the triple workday they must cover, given their gender role within the social structure. Although in a structured way they may seem to be isolated elements that address various institutional problems, the truth is that they not only mark the impact of women on their environment but also how this environment, for natural and social reasons, affects them in a differentiated and historical way, whose framework, if not addressed, will limit the development of the region and above all, more than half of the population will be the main victims of its negative effects in the short and long terms.

At this point of the research, it is clear that it is impossible to separate one problem from the other, since their effects are reversible between them. By increasing gender inequality in a transversal way, they will have a lower capacity to face the conditions of climate change, and this will generate greater inequality, and a slow response to climate conditions in a structured way. While, in a social deconstruction for the defense of their rights, the arrival of the pandemic can be addressed through a collective defense built from equity and sustained in the institutional framework.

Case Studies

Given the above considerations, in the Latin American region, a broad portfolio of strategies related to climate change and its distribution [10] between adaptation and mitigation to climate change has been unleashed; however, its complex implementation requires considering the specific circumstances of the region, among which the double inequity due to gender inequality, and, above all, the implications of these strategies in the social agenda of Latin America and its integration into the development agenda stand out.

To support understanding, this research considers the concepts of the Intergovernmental Panel on Climate Change to define climate adaptation strategies as those that seek adjustments in natural or human systems in response to climatic stimuli and their effects, which can moderate the damage or take advantage of their beneficial aspects [11]. These actions are particularly focused on the forestry, biodiversity, agriculture, and water sectors; while projects aimed at climate change mitigation are all of the anthropogenic interventions that aim to reduce human alteration of the climate system, such as reducing sources and emissions of greenhouse gases and improving the removal or sequestration of greenhouse gases [12]. These types of strategies have focused on the energy, transportation, agriculture, forestry, and waste sectors.

In the case of Table 1, the selection criteria of the projects were developed according to the availability of information for each project, which would allow us to gather information regarding the main research questions to explore or verify the presence of the gender perspective in the environmental projects of the region as a form of double mainstreaming. We can observe that three of the main climate action projects in the Americas are linked to access to the means of production, specifically the energy sector. Their analysis is based on verifying the gender perspective in their actions, and each of the determinants were identified thanks to the results of the previous sections. Thus, our conclusions in the table will focus on whether the results of each project were based on the gender perspective.

Table 1. Own elaboration and analysis with cases in Latin America, 2020 [13].

Criteria	**Countries**		
Contextual Approach to Vulnerability	**Nicaragua**	**Guatemala**	**Salvador**
What is the current situation (in relation to education, health, access to means of production, etc.) of women and men in the region where the project is formulated in terms of vulnerability to climate change and other contextual changes?	The PELNICA project improved household electrification in the residential sectors of 379 communities, benefiting 90,000 people in six years, including electrification of workplaces where men work, while electrification of homes and schools was limited.	The project for the productive use of renewable energy in Guatemala did not initially consider gender issues in its design, so it centralized actions in public spaces, without addressing generalized needs in society.	The project on the use of geothermal energy and its (unused) residues sought to empower women economically and strengthen their leadership in the communities surrounding the geothermal plants.
What options are considered to strengthen the gender perspective in the project?	Gender elements are not considered; its main purpose is to increase electrification to improve access in a generic way in the community.	It is not considered. It is identified that the sectors that benefited were only the central ones, the busiest ones, and not those that will be used by the most vulnerable groups, such as those surrounding schools, women's workplaces, or dangerous neighborhoods that women will travel through to a greater extent, in such a way that the needs of women in public spaces were completely ignored, and their participation in the project planning groups was limited.	The active participation of women, thanks to the project's links with women's daily activities, made women's work outside their homes more visible, and led to priority areas of attention, such as energy and sustainable ecosystem care.
			As part of this work, girls and adolescents from the schools also participated in the dissemination of information, which helped to improve integration based on the defense of nature and human rights.

Table 1. *Cont.*

Criteria	Countries		
Contextual Approach to Vulnerability	**Nicaragua**	**Guatemala**	**Salvador**
Will the project change women's and men's roles in any way and/or perceptions of these roles?	No, and it is even identified that the perspective of improving production over other elements strengthens the stigma that women's work within their homes is not productive and should not be a priority since it does not represent economic benefits, limiting actions that address and strengthen it.	No, it will maintain the conditions, prioritizing electrical adaptation over collective benefit. Gender bias is not increased, but the existing conditions are maintained, which is contradictory to the ideals of progress proposed in the initiative.	It will integrate them under a perspective of gender equity, active participation, and valuing different activities equally. Likewise, the information campaign that was launched in the community's schools will help to replicate the ideals of equity in different generations, which will help to improve the conditions of women in the short, medium, and long terms.
What options are considered to strengthen the gender perspective in the project?	Gender elements are not considered or ignored in the formulation and development of the project.	Potential is seen in helping collectives and training spaces for women, but they are not contemplated in the approach, and the starting point is a generalized floor that leaves the conditions for improvement unbalanced.	Greater integration of women in the labor sectors and of household activities with respect to environmental protection are key to strengthening the gender perspective in the community.
Conclusions	The project did not have continuity since the prioritization of attention to spaces that was maintained did not allow for its expansion.	The project experienced challenges in promoting gender equality in rural areas since, in general, their work is undervalued and there is limited access to their participation outside the domestic space and their capacity to undertake productive activities is limited.	Women's livelihoods were increased. In total, 40 women from 15 communities around the geothermal plants benefited economically from the process.
	On the other hand, it is identified that its distance from the gender perspective limited the participation of women in the project and widened the biases of participation in the public sector and decision making in a diverse way.	A situational analysis of gender conditions was not carried out, so the following are not known.	Likewise, the gender perspective was included in the program from the beginning, which helped to ensure that the actions would have this vision in a cross-cutting manner and improve equity conditions.
	In this case, the gender perspective was not considered, and this limited the results.		

Source: Banco Interamericano de Desarrollo [13].

Part of the limitations found in each project arise from the isolated approaches between each situational approach per project, and above all from a bias of social vulnerabilities at a historical level in Latin America; that is, it does not consider the differentiated effects of both climate change and the strategies that address it. A situational analysis is developed in two cases, which identifies the socioeconomic conditions, but the data is not disaggregated

by sex and gender, which meant that the analysis did not collect what was necessary to mainstream the gender perspective in the actions. Therefore, we cannot conclude that the advances in gender are representative in terms of the needs that this problem demands, which limited the scope of environmental matters. This led us to verify our initial analysis, in which it is stated that if the gender perspective is not included in the projects, by prioritizing other terms of growth and infrastructure progress (in this case, electrical adaptation), the projects will not have a representative social benefit, since they start from gender biases, replicate stigmas, and strengthen a social infrastructure fragilized by these elements. Therefore, the development proposed by the SDGs only finds its integrity in theory.

As the evidence shows [14], climate change projects in the Latin American region are currently facing great challenges, since in their integrity they must maintain constant levels of economic growth, address the constant struggle for the historical levels of inequality, which are expressed with an emergency character in terms of sectoral vulnerability, and which particularly affects the service sector: rural. The effects of the social crisis, such as gender inequality and development gaps, must also be mitigated, as well as the mainstreaming of the principles of common but differentiated responsibilities in climate mitigation and adaptation projects, as proposed by [15], in order to achieve consistency with sustainable development. This would be easier to develop if we work at the regional level through an inter-institutional collaboration that addresses the integral needs of the communities in which it is developed, through a perspective of simultaneity and common collaboration. In this case, Civil Society Organizations (CSOs) should be integrated with feminist collectives to take advantage of local female leadership, normative and human rights institutions, environmental policies, women's institutions, and other vulnerable collectives due to gender, in order to integrate an integral perspective that can provide common attention and action in the face of an accumulated crisis.

3. A Series of Recommendations: Between the Environment and People

The results of the research make it clear that the effects of climate change are not a gender-neutral issue. Therefore, the double transversality in climate adaptation and mitigation initiatives are the fundamental guide for the formulation of our agenda, and we consider that the main elements to achieve a social transformation in terms of gender must be transversal. This is contrary to what we found in the cases studied, in which the gender perspective was an isolated element of the construction of these types of initiatives. To ensure that development and its benefits reach all people, these projects must be based on the resolution of social vulnerabilities differentiated by sex and gender.

In view of the above, there are seven fundamental lines of action to which these vulnerabilities have been concentrated, such as agricultural production and food security, access to the means of production, water resource management, forest resources and agroforestry, disaster prevention, migration, and public health. The general recommendations described below are intended as an outline of an early warning route to address the issue. They need more precise analysis in each case, adjusted to the circumstances of the institutional transformation required to make mainstreaming a programmatic line as part of the climate agenda at different levels, and create links between agents that are present at the intersection of gender and climate change, in local communities and among decision makers, to promote synergies and joint commitments to strengthen actions that transform the climate agenda. This requires the development of a situational analysis that allows locating the historical and differentiated context experienced within the region; thus, this baseline is taken as a reference in the framework of the formulation of gender mainstreaming strategies in climate policies, in such a way that the continuums are incorporated. Within the institutional action, we consider that it is relevant to strengthen gender capacities within organizations and government agencies that ensure continuity of gender-responsive actions and extend to all stakeholders.

In other words, a gender perspective training framework should be established in a conceptual and practical manner, so that any action aimed at resolving this double inequity does not reproduce the gender biases that have traditionally developed in the Latin American region, and that have caused the innovations implemented in the area of climate to widen the gaps that affect women. This framework of reference should propose training and capacity building links with the communities, so that this perspective becomes an integral element in the climate actions in such a way that the community is involved in the main transformations expected from the projects. Even though it is not an institution specialized in gender, the current emergency demands it.

- To outline monitoring and evaluation material from a gender perspective, i.e., that within the formulation, practicality, and technical contribution of the projects, gender indicators are constructed, from the situational analysis in which the projects are developed, to the gender implications of each project, which will allow us to monitor and evaluate policies and initiatives effectively.

All these schemes should be linked to legal and institutional frameworks, to ensure that social norms are directed towards the protection and safeguarding of women's human rights, to increase the possibilities for a tool for gender-responsive climate policies. All this will lead to a co-responsibility of environmental, economic, and social defense.

- Promote a more active role of women and their organizations in the discussions and decisions being made in the climate change arena and encourage a more balanced representation of women and men in public decision making in general, ensuring that women's perspectives are heard. This will improve and guarantee women's access to and control of natural resources and provide measures for capacity building and technology transfer, even though communities are remote or more technologically and socially vulnerable.

This will help us to take advantage of the leadership capacities of women that have been identified in them at the local level, and thus, take advantage of the specialized skills of women in mitigation and adaptation strategies. To this end, it is necessary to create equitable conditions and opportunities for education, information, and training on climate change and gender equity, which can be initiated by strengthening the channels of social control and communication, as implied by social networks and other digital platforms. On the other hand, these actions can be achieved by developing channels between women's environmental defense collectives and institutions.

- Develop processes to strengthen the autonomy of the social, economic, and participatory powers of women and other vulnerable groups, based on a characterization that defines the specific needs of each social group, through a fiscal, social, economic, and climate policy agreement, to support the high level of uncertainty of this population sector.

This will allow women to respond to the problems and needs they identify, incorporating their perspective in the design, implementation, monitoring, and evaluation of gender interventions and public decisions in our country and at the international level on climate change. Among these discussions, it is worth introducing proposals such as a universal basic income, a basic basket of digital products, and the safeguarding of environmental rights, regardless of the sector to which women belong.

- Mapping the mechanisms or spaces already existing in the different public, private, and Non-Governmental Organization (NGO) instances such as social networks, virtual interactive platforms, consultation spaces, radio programs, and other activities of women's organizations that are developed in our country. For example, those organized within political institutions, educational centers, and community centers, to create work networks together with the institutions, which will have positive effects on the dissemination, construction, and protection of development mechanisms and strategies, specifically those of climate change. To approach the relevance that

technology has in the life of Mexican society, which requires exploring the level of access that they have to the indispensable equipment; thus, to include them in the processes of communication, transparency, and political participation. Develop changes in regulations, accompanied by a transformation of the organizational culture, of political power relations, and of the relationship between social subjects and the state apparatus. To bet on greater regional integration, in which initiatives are mediated and regulated in Latin America to make this union a collective defense mechanism for women, such as the integration of a regional agreement to build a feminist policy for environmental protection that not only addresses migratory parameters and territorial mobility, but also covers other international needs, such as labor, security, trade, and research. Directly address the vulnerabilities of the Latin American context, which are identified in the baseline or initial situational analysis to address them without biases or contradictions of the development objectives. To regulate the causes, conditions, and determinants in which migratory flows develop in the region, as well as the economic activities in which women must also engage, or to which they must dedicate themselves again after the transformation of their socioeconomic environment, in case they have migrated or have more responsibilities in their place of origin.

The list of these elements is not directly limited to the sector specified, i.e., by addressing migration, economic conditions are also addressed, and vice versa. On the other hand, by promoting women's participation in the public sector and in social decisions, gender parity is improved and women's capacity to adapt to the effects of climate change is strengthened, as an integrity that characterizes development.

4. Conclusions

In consideration of the cases presented in this research, in which we found a generic isolation and abandonment of the gender perspective in their approaches and actions, and its contrast with the context of the double gender inequity and the differentiated effects that this generates in environmental matters, allows us to show that the projects that should be prioritized in the region are those oriented towards climate adaptation of local character, that allow them to be close to their population, and above all that imply the analysis of their social and cultural transformations, in an integral matter of development, as a multidimensional phenomenon. Therefore, it is not only expected that the projects are gender transforming in the climate, but also in the forms of social organization of the economic structure; thus, the gender approach that we take as a premise of this research maintains gender relations as a transversal theme in the analysis of all the areas of intervention. This should go hand in hand with a monitoring and evaluation scheme with indicators focused on ensuring that these projects do not reinforce the unequal gender patterns that have traditionally guided Latin American communities, as the evidence shows. Therefore, the formulation of measurements should integrate the contextualization and transformation of both sexes and gender expression. Although the valuable effort of Latin America regarding the integration of the gender perspective is recognized, it was reflected that this is not systematically applied in the identification and implementation of projects and programs in the field of development in general, and even less in the specific case of climate change. Therefore, we would like to highlight the relevance of considering the socio-cultural norms and existing exclusions in the context in which we work, for this perspective to be integral and beneficial. In summary terms of our agenda, this requires contemplating the differentiated needs and capacities between men and women in climate matters, so that these are the basis for the formulation and prioritization of climate actions, evaluating and measuring the integral implications for each specific sex, and integrating the intervention actions specifically aimed at challenging gender inequalities.

Thus, not only were the importance of the gender perspective in the agenda and the defense of equality highlighted, but also the urgency of a crucial reconfiguration. For example, a global agreement of a transversal nature in its proposals that does not

attend to goals in periodic terms and focuses on the development debts that are currently expressed as serious socioeconomic and environmental problems that are particularly worrying for women. Including simultaneous short-, long-, and medium-term visions is important. The current findings are the result of a theoretical–practical isolation of the integral approach to development that requires us to become savage fighters in the fulfillment of its proposals [16]. Therefore, the mainstreaming of this perspective in the agenda becomes the axis of its reconfiguration, not only in the search for gender equity, but also for the equity of socioeconomic development and peace that this agreement seeks to achieve. Although the conditions described above do not by themselves guarantee gender equality and the closing of gaps, this analysis is relevant in terms of the reconfiguration of a robust framework for action as a solid basis for mainstreaming the gender perspective for climate decision makers in the region.

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Proceeding Paper

Vertically Integrated Projects for Sustainable Development: Achieving Transformational Action by Embedding Research-Based ESD in Curricula †

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Abstract: The University of Strathclyde's Vertically Integrated Projects for Sustainable Development (VIP4SD) programme has grown to become a key vehicle of Research-based Education for Sustainable Development at the institution. The programme enables students from different disciplines and levels of study to work with experienced researchers on diverse projects which address the real-world problems outlined by the Sustainable Development Goals. This paper discusses the challenges encountered in transforming VIP4SD into a mainstream activity, and explores how this has inspired a whole institution approach to embedding ESD throughout Strathclyde's curricula.

Keywords: higher education; education for sustainable development; student experience; competencies; graduate employability; graduate skills; research-based education; intercultural learning; vertically integrated projects

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1. Introduction

The University of Strathclyde's flagship Vertically Integrated Projects for Sustainable Development (VIP4SD) programme is embedded in the formal and informal curriculum and encourages students to work in partnership with experienced researchers and academics, and with their peers from different disciplines and across all year groups to create student-centred research projects focused on the Sustainable Development Goals (SDGs).

The programme is designed to develop the core competencies of Education for Sustainable Development (ESD) through an immersive 'real-world' educational experience that aims to provide a "transformative learning environment" that enables students to engage in "transformative action" through ESD [1], and so not only "prepare our students for the world of work, but to tackle the work of the world" [2]. It does this by embedding ESD in curricula through the use of Research (or Inquiry)-based Education (RBE or IBE).

The paper will explore Strathclyde's experience and the challenges it has encountered in taking the programme from pilot to mainstream and how this has inspired a whole institution approach to embedding ESD more generally in Strathclyde curricula.

2. Vertically Integrated Projects and Research-Based Education

Vertically Integrated Projects (VIP) is an innovative style of RBE that came to the University of Strathclyde from the Georgia Institute of Technology (Georgia Tech), where it was originally conceived. The VIP model evolved from a teaching programme initially implemented at Purdue University in 1995—The Engineering Projects in Community Service (EPICS) programme [3], through which students participated in long-term, practical engineering projects focusing on delivering specific outcomes aligned with local community

needs. At Georgia Tech, this model was honed to introduce a more research-intensive dimension, where student teams were built to address unstructured problems associated with broader 'real-world' and applied research areas—though still with an engineering and technology focus [4,5]. The International VIP Consortium, consisting of almost 50 Higher Education Institutions (HEIs) adopting this model for integrating RBE in undergraduate teaching, was formed in 2012, and primarily serves as a community of practice around VIP implementation.

Other approaches, such as UCL's Connected Curriculum [6], have espoused the merits of embedding RBE in and across (or connecting it with) all dimensions of the curriculum; and so too does the VIP model. From the students' perspective, it is the unique vertically integrated dimension of the VIP model that affords the time and space and (to some extent) academic freedom necessary for meaningful and impactful research, as well as the development of personal and professional skills and competencies. From the project or research perspective, this vertically integrated dimension enables projects to plan for, and focus on, long-term, ambitious, and wicked problem areas, safe in the knowledge that a constant stream of student research resource will continually be available. The multi-year group structure of the research teams means that there is always an overlapping period where junior and senior team members work collaboratively to advance the research of those who have come before them and set the future research direction of those who will follow.

3. VIP4SD—Research-Based Education for Sustainable Development

The University of Strathclyde implemented VIP as a pilot in 2012, where interested researchers and academics were approached to become 'VIP leads', with support given to build and supervise undergraduate research teams that could enhance existing research projects or explore new research. The model worked well at Strathclyde as it had at other institutions, but scaling and mainstreaming of the programme (beyond 8–10 teams) is a high inertia challenge without the all-important institutional buy-in and support required to scaffold a whole institution approach to implementation.

Key to achieving buy-in was a strategic decision taken by the programme proposers and directors, which was to align two strategic educational objectives of the institution. The first was to cultivate opportunities that could exploit the nexus around teaching and research to develop more collaborative research opportunities for students, which could have co-benefits of providing an authentically experiential learning experience for students while bolstering research groups with this additional resource. The next was to develop experiential learning opportunities for students around sustainable development. By strategically aligning these objectives and using the VIP model as a vehicle for delivering this, the programme was re-imagined as the Vertically Integrated Projects for Sustainable Development programme (VIP4SD) in 2016 (the year the SDGs came into being) – effectively combining RBE with ESD to offer a proven means of embedding Research-Based Education for Sustainable Development (RBESD) in curricula. Other institutions have implemented similar programmes to great effect, such as KTH Stockholm's Global Development Hub, which embeds 'Challenge-Based (or Driven) Education' in their curricula [7].

The inherently multi- and inter-disciplinary nature of the sustainable development agenda necessitated that the formation of the teams be objective-based (or challenge-driven), and therefore presented a prime opportunity to diversify the programme from being predominantly engineering-centric to being more interdisciplinary. This required targeting collaborations around new staff and student cohorts, from different disciplines, departments and faculties. Consequently, the programme at Strathclyde had the cause and challenge-driven justification to add this cross faculty (horizontal) dimension to the already vertically integrated model to meet the interdisciplinary needs of the SDGs.

Examples of VIP4SD projects are:

- *Can Democracy Deliver* (SDG 16)—employs a range of student disciplines to examine the linkages between the quality of democracy, citizenship, infrastructure, service delivery, and quality of life in developing countries;
- *Building Pandemic Resilience* (SDG 3, 9, 11)—aims to develop methods of using Indoor Environmental Quality (IEQ) metrics to rapidly inform best practice for managing and designing buildings to enhance the health and wellbeing of occupants, initially by informing short and long-term COVID-19 disaster responses;
- *Community Engagement and Glasgow Children's University* (SDG 4, 10)—aims to develop a web-based tool for the collation, co-ordination and promotion of credit-bearing (and outreach) activities that can be drawn together from learning activities across the University (and potentially beyond) to service the Glasgow Children's University [8].

ESD has been criticized for its vagueness, but UNESCO's framework for the implementation of "ESD for 2030" acknowledges that while this may be the case it can be addressed more concretely when ESD is linked with the SDGs. It states that "the 17 SDGs, which encompass the issues related to development and sustainability in a single framework, offer to the global community a renewed window of opportunity to reinforce this fundamental function of ESD" [9]. Therefore, while the projects are structured along these vertically and horizontally integrated lines, the programme's research project portfolio uses the SDG framework to provide a clear identity and purpose for individual projects, while retaining the sense of interconnectedness that exists in the relationships between the goals and VIP4SD projects.

The moral imperative attached to Agenda 2030 is the overarching global objective unifying all VIP4SD research teams; giving a common sense of purpose across the entire programme; raising the stakes of teaching and learning and working to motivate and inspire students to engage in a deeper level of inquiry and learning through RBE.

This alignment of key strategic objectives including interdisciplinary RBE and ESD (together forming RBESD), the narrative of Strathclyde students contributing positively and collectively to Agenda 2030 as an integral part of their studies, and its resonance with the institution's socially progressive traditions and ethos of being "the place of useful learning," created a potent and compelling narrative which served the programme well when securing the institutional buy-in required to mainstream VIP4SD and subsequently embed and mainstream ESD more generally.

4. Implementing VIP4SD in Higher Education—The Strathclyde Perspective

Continuing the progress made during the Decade for Education for Sustainable Development, the Global Action Programme for ESD (GAP) sought to "integrate the principles of sustainability into educational strategies and action plans" at national, local and institutional levels [9]. In 2020 a new UNESCO implementation framework for ESD is available along with other guidance documents, offering practical 'how to' support, tools and guidance that will allow institutions to more easily adapt and integrate ESD for their institutional setting and context.

A reflection on the approach to mainstreaming and embedding VIP4SD (and RBESD) in Strathclyde curricula recognizes a close alignment with the UNESCO approach [10], with much of the QAA/AdvanceHE ESD guidance also resonating [11]. The broad action plan followed to mainstream and embed VIP4SD in Strathclyde curricula involved:

1. SDG Mapping;
2. Raising awareness, gathering buy-in, building activism and capacity;
3. Identifying and addressing barriers and challenges for VIP4SD;
4. Monitoring and evaluation of VIP4SD programme;
5. Building partnerships and share knowledge/practice.

4.1. Mapping SDGs to Existing VIP Projects

Following the decision to realign the existing VIP programme with the SDG framework, it was necessary conduct an SDG mapping exercise across existing projects. Given how comprehensive the developed SDG framework is in terms of addressing the principal environmental and socio-economic problems facing humanity, it proved extremely easy to map existing VIP projects onto one or more SDG targets. Reassuringly, though perhaps not surprisingly, there was no requirement to 'shoehorn' SDGs into VIP projects (or vice-versa). However, it was key to ensure that the VIP leads had already bought into this realignment to avoid undermining their position as project initiator and inventor; to respect their continuing role as project lead and director; and to ensure that the SDG context added gravitas and was viewed positively as a different lens through which students would meaningfully engage.

4.2. Raising Awareness, Gathering Buy-In, Building Activism and Capacity for VIP4SD

As mentioned previously, creating a powerful and engaging narrative for the programme was a key component to securing buy-in. However, it was equally important to demonstrate its practical implementation and scalability. Perhaps what made the case most compelling was the staff, student and stakeholder testimonies evidencing (albeit anecdotally) the impact and efficacy of the pilot programme. Some level of external peer review and recognition through publications, blogs, and articles, as well as national and global awards [12,13], was also key in raising the profile and awareness of the programme and securing the confidence and institutional buy-in required.

Ensuring capacity for staff was critical to building a culture of confidence amongst staff to deliver new programmes involving unfamiliar and disruptive approaches such as VIP4SD. To achieve this we needed to provide support that reinforced the practices and processes that underpin the successful supervision of VIP4SD projects, as well as effective programme delivery. To aid this, a new VIP4SD coordinator role was created with a staff appointment made to this position, and an appropriate staff induction was developed with a Strathclyde community of practice established through regular VIP4SD lead meetings designed to share good practice and lessons learned across the programme.

Project capacity is also an ongoing challenge, but one that is expected to ease further once a critical mass is achieved and more momentum gained. The catalyst to attracting leads and projects, which supports sustainable programme growth, is incentive provision. Specifically, this entails the recognition of VIP4SD roles in career development pathways and the provision of project funding—as discussed below.

4.3. Identify and Address Barriers and Challenges for VIP4SD

The main challenges in the implementation of the VIP4SD programme exist around:

- Institutional promotion and acceptance (buy-in): This has been discussed in Section 3, but a key recommendation is the development of a 'small-scale' proof of concept pilot to enable the building of a case, supported by staff and student testimonies, for programme scale-up and mainstreaming;
- Academic regulations, curriculum changes and credit structures: 'Container classes' (i.e., project-based classes with equivalent learning outcomes), electives and also extra credit options were used to create vertically integrated pathways through ascending years of degree curricula;
- Project resourcing and student engagement: Staff provided modest seed funding for projects and brokerage events where project leads pitch to students. Students apply for team selection via a specially designed VIP4SD application portal, which matches project requirements with year groups and degree disciplines exhibiting vertically integrated pathways. It is important to recognize here that the approach to mainstreaming has been challenge- and project-driven, where pathways are developed in accordance with 'live' projects. In addition, staff participation in the VIP4SD programme must be fully acknowledged in workload models, development reviews

and promotion cases. In terms of promotion amongst students, beyond 'word of mouth' building evidence to promote the positive impact on the student learning experience requiring monitoring and evaluation of the programme (discussed in Section 4.4). Another resource requirement and incentive for staff uptake is the provision of project funding. Strathclyde has worked with its Alumni and Development Department to attract successful donor funding. The obtained funds are then dispersed through VIP4SD seed funding calls (e.g., often aligned with themes such as COVID-19 response, COP26 legacy, etc.), internship funding and "VIPer Pit" prizes, where students pitch for project research funding to a team of stakeholders from private, public, and third sectors;

- Degree accreditation requirements: Important to advocate for extraneous change to degree accreditation criteria involving the explicit inclusion of elements of RBE and ESD in order to affect change inside;
- Assessment and supervision: While there is flexibility for different leads to develop different assessment methods and criteria, there is a desire to move towards a consistent (though not completely rigid) approach involving methods of group assessment such as project reports, conference poster and Pecha Kucha presentations.

4.4. Monitoring and Evaluation of VIP4SD Programme and Development of ESD Competencies

Monitoring and critically reflecting on progress is clearly important to ensure the programme is scaling universally and consistently across the institution, and that is having the intended impact on students and target communities and stakeholders. At Strathclyde we are in the process of capturing and analysing feedback primarily through staff and student surveys and focus groups. One student survey we have developed is intended to allow evaluation of the programme's efficacy with respect to ESD competency development in particular.

The OECD and WEF are among many to have defined what they consider to be the employment and career skills of the future [14–16]. The OECD defines skills as part of 'a holistic concept of competency, involving the mobilisation of knowledge, skills, attitudes and values to meet complex demands' [14]. The complex demands that business and industry will face in the future will therefore require employees and graduates competent in helping employers meet these, which is being increasingly recognized in ESG strategies. Whilst variations exist in how these competencies are defined and prioritized, there are overlaps [17]. Wiek et al. presented an interlinking, ESD competency framework consisting of five key competencies identified as Systems Thinking, Anticipatory, Strategic Thinking, Interpersonal and Normative, and emphasized the need to enable students to not only develop these individual competencies, but to 'combine these competencies in a meaningful and effective way' [18]. However, doing so in ways that competency development can be evaluated and evidenced effectively remains challenging.

Building on the work of Weik et al., UNESCO ESD competencies represent a broad global consensus on the core ESD competencies [19]. UNESCO define these as a set of related knowledge, skills and abilities that result in essential behaviours. They focus on a set of eight competencies building on those identified by Wiek et al. The QAA and Advance HE ESD Guidance mentioned previously is based on and framed around these UNESCO competencies, categorizing them as ways of thinking, being and practicing. These categories align with Orr's initial approach to what was regarded as ecoliteracy education and built upon by others to achieve transformative sustainability learning by engaging the head (cognitive), heart (affective) and hands (psychomotor) domains [20].

It is these robust and well-acknowledged ESD competency frameworks subscribed to by UNESCO that Strathclyde has chosen to use as the basis of measuring student skills development and its programme efficacy, which is work still in progress. The so-called "articulation of skills gap" addresses the fact that despite possessing key competencies and skills, VIP4SD students may be unable to identify and articulate these effectively to themselves or others (for example, employers). To address this, work is ongoing with a third

party enterprise to develop an experiential learning support platform that will prompt and enable students to record, understand, track and articulate their own competency development derived directly from their participation in VIP4SD – effectively the What, When, Where and How they developed these competencies through their VIP4SD journey. This will culminate in the compilation of a portfolio of tangible evidence demonstrating their competency development accompanied by corresponding STARS reflections (Situation or Task, Action, Result and Self-reflection). This will also provide a clearer insight into the efficacy of the programme across the VIP4SD cohort, moving beyond a reliance on anecdotal evidence and towards a more robust framework for capturing and evidencing student competency development as part of their transformational VIP4SD learning journey and the effectiveness of the broader programme.

4.5. Build Partnerships and Share Knowledge/Practice

In addition to the internal community of practice mentioned previously (Section 4.2), external partnerships through the International VIP Consortium has also proven to be a very useful knowledge-base, where institutions, despite their geographical diversity, still experience many of the same challenges (some outlined above), and can therefore share common solutions. The consortium is currently developing a VIP handbook for institutions that will formalize this support for start-up and established VIP programmes.

Strathclyde has also been keen to share its own VIP innovation – its alignment with ESD being its principal innovation – both with partners inside the consortium and with other, non-VIP institutions. Of these institutions, there are some that are already operating similar programmes (for example, KTH Stockholm's Global Development Hub); some which have expertise in other areas that could further enhance the VIP4SD model and its impact on the student experience (for example, COIL and VEIL, discussed in Section 6); and some institutions that are just beginning their journey to embed RBE and ESD into their curricula. In addition to institutional and staff partnerships, more can be done to enhance opportunities for greater partnership between students, particularly cross-institutional, international student research partnerships through the adoption and integration of COIL (see Section 6).

5. From VIP4SD to ESD@Strath

The demonstrable practicality of embedding RBESD through the VIP4SD programme was a key factor in achieving institutional buy-in to "[place] Education for Sustainable Development (ESD), aligned with the UN Sustainable Development Goals, at the heart of its curricula" [21]. It is recognized at Strathclyde that if education is to be oriented toward sustainability, then this will require a whole-institution approach involving changes to processes and practices as required, and involving all faculties, departments, professional services, operations, relevant groups and our Student Union.

New programmes and modules with a dedicated focus on sustainable development (like the VIP4SD programme) should be created and promoted; but to ensure ESD is meaningfully "placed at the heart of our curricula" and sustainable development made relevant to all of our students requires ESD not being treated as a thematic topic. ESD must be woven into the fabric of the formal, informal and subliminal curricula. Only then can the principles and practices of sustainable development be fully integrated into all aspects of education and learning—and ESD embedded within all courses (existing and new) to ensure a comprehensive and sustainable institutional contribution to SDG 4.7.

Strides are being made in this direction at Strathclyde with the launch of its new Centre for Sustainable Development (CfSD) which is coordinating a whole institution approach to Strathclyde's contribution to the progression of the SDGs. This will bring a coherence to the University's own global, socially progressive vision, and focus its long-standing research and education work on sustainable development into a single strategic approach. The "Education and Activism" thread of the CfSD is now actively implementing its ESD@Strath action plan, following a very similar approach to that followed and outlined above, but now

with a more holistic, expansive and all-encompassing remit and approach to embedding ESD more generally.

6. Future Opportunities for VIP4SD

As the VIP4SD programme continues to expand across (and potentially beyond) the University of Strathclyde, there are plans to further enhance the programme by adding a new global and intercultural dimension to the existing vertical (inter-year) and horizontal (interdisciplinary) dimensions already discussed. Our diversity in an increasingly interconnected world is a key asset, and global collaboration in every sense will be key to harnessing this and achieving climate change adaptation and mitigation in a way that is socially and economically progressive. Ensuring innovators, technologists, business leaders and citizens of the future exhibit the global competency that is so critical to achieving worldwide sustainable development.

Education for global competence builds on the ideas of different models of global education, such as intercultural education, global citizenship education and education for democratic citizenship. Global competence is now (from 2018) an integral part of the OECD's PISA framework. It defines global competence as "the capacity to examine local, global and intercultural issues, to understand and appreciate the perspectives and world views of others, to engage in open, appropriate and effective interactions with people from different cultures, and to act for collective well-being and sustainable development" [22]. This global competency must be embedded, enabled and nurtured within ESD; particularly in experiential ESD offerings such as VIP4SD, as this can lead to a genuinely transformational learning experience and will result in more globally and culturally rounded graduates. However, relying solely on international student mobility (ISM) to develop this global competency at best prevents this from being widely accessible and at worst can be considered non-inclusive and elitist (as clearly not all students have the financial or social capacity, and therefore equal opportunity, to participate). Furthermore, given how selective this can be, relying solely on ISM as a vehicle for intercultural engagement is not only arguably unethical, but it is also both uneconomical and un-scalable if it is intended for wider deployment as an integral component of ESD.

The global network that is the International VIP Consortium represents fertile ground for interdisciplinary, international and intercultural research collaboration between undergraduate students working on wicked global research challenges. Here, students' intercultural competency is being developed to improve engagement with their international research partners (from other VIP sites – the Building Pandemic Resilience project outlined above is a partnership between Strathclyde and Purdue Universities), as well as the stakeholders and communities on which their research centres. Strathclyde academics experienced in facilitating 'Global Classrooms' and Purdue's Center for Intercultural Learning, Mentorship, Assessment and Research (CILMAR), which makes of use of tools such as Intercultural Development Inventory (IDI) to assess and evaluate IC and the Intercultural Development Hub (IDH) to share intercultural learning activities, assessments, and publications, will bring their experience of VEIL (Virtual Experiential Intercultural Learning) to provide scaffolding and training for both staff and students engaged with COIL [23,24]. Meanwhile, the VIP Consortium is discussing the possibilities around the practical support it can offer by way of developing 'matchmaking' sessions and tools to facilitate more coordinated and integrated COIL and VEIL activity across the VIP consortium.

7. Conclusions

The 'idea of the University' has shifted over time, where the contemporary model of a research-intensive, state and/or entrepreneurial University has evolved and morphed into a 'being' with traits remaining and inherited from antecedent models [25]. There is some debate over whether the 'idea of the University' is to allow for the pursuit of knowledge 'for its own sake', or to 'enable economic and societal progress through a developmental model involving wider community and stakeholder engagement' [26]. Or, perhaps it is both of

these things and more, in line with the so-called 'multiversity', involving an interconnected multiverse of stakeholders involving HEIs, governments, businesses, industries, NGOs, etc. [27]. Putting such debates aside, what is clear is that all of these key actors will be required to work collectively to achieve global sustainability, and—critically—it is incumbent upon HEIs to generate the sustainability-competent graduates these actors need.

To achieve this 21st Century graduate for our times, this paper promotes the need to embrace and reimagine the central Humboldtian principle of the 'union of teaching and research', but with a clear focus on wicked global challenges—the classical view of universities is of 'a community of scholars and students engaged in a common challenge' [27]. This paper presents the VIP4SD model as a practical and workable means of embedding interdisciplinary RBESD in HE, where students can work partnership with each other across year groups, disciplines, departments, faculties, institutions and borders—and with academics—to contribute meaningfully to the universal challenge of advancing sustainable development.

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Proceeding Paper

Securing a National Water Policy in Guatemala: Understanding Barriers and Potential Implementation Strategies through Comparison with the Establishment of Regional Mining Laws †

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Abstract: Guatemala has proven an informative case study into the many barriers which inhibit the establishment of comprehensive national water policies (NWPs) in low- to middle-income countries (LMIC). The country has formally established the right to adequate sanitation and drinking water many times over: through the ratification of three international treaties, two water-specific constitutional articles, and regulatory bodies for infrastructural projects. Despite these measures, the existing water policy is piecemeal, and each of the at least 13 attempts to establish an NWP over the last century has stalled in Congress. As a result, poor infrastructure and industrial abuse of waterways have made water accessibility and sanitation constant concerns for generations of Guatemalans. Here, we investigate the many factors which have led to the recurring failure to establish an NWP in Guatemala. Following this investigation is a comparative analysis between barriers inhibiting the establishment of an NWP and those which face another Central American sector historically rife with human rights abuses: mining. Notably, major gains have been made with regard to the mitigation of harms enacted by the mining industry in several Central American countries, with the closing of several major mines in Guatemala, a pit-mining ban in Costa Rica, and the world's first blanket ban on metal mining in El Salvador. We identify factors which have led to the success of the mining ban in El Salvador—namely, coordinated community involvement from campesinos to the traditional oligarchy, grassroots strategizing which snowballed from local referenda to national policy, and the leveraging of international attention—and make suggestions for their implementation with respect to the establishment of an NWP in Guatemala. This project is part of an ongoing, mixed methods research endeavor examining factors impacting water security in Northern Triangle countries (Guatemala, El Salvador, and Honduras), especially as the region's weather patterns become more erratic and intensified under climate change.

Keywords: Guatemala; El Salvador; water; mining

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1. Introduction

The implementation of a national water policy (NWP) is long overdue for the Republic of Guatemala. The country's natural weather patterns result in a high quantity of but highly variable rainfall, with each year cycling between rainy and dry seasons often marked by drought and tropical storms. The intense seasonality of surface water availability alone makes a compelling case for the institution of an NWP, given its contribution to inequity in water access. Additionally, however, the development of such a law is explicitly written into the 1985 Constitution, which defined water as a public good to be regulated by a national law [1]. Despite this constitutional mandate, 13 proposed NWPs have stalled in Congress since 1985 [2], with the most recent, Iniciativa 5253, still under review four years after its proposal [3]. Though Guatemala has signed a number of international agreements, treaties, constitutional provisions, and internal water resolutions which clearly state its

support for the human right to clean water [4], state performance regarding the issues of water and sanitation are poor, with the 2016 environmental report by the Ministry of Environment and Natural Resources (MARN) showing evidence of contamination in the majority of water basins, contributing to frequent generalized water contamination notices, shortage problems, and poor sanitation and drinking water services [2,5].

Here, we investigate the many factors which contribute to the recurring failure to establish an NWP in Guatemala. We argue that a democracy characterized by weak institutions and corruption fueled by local and international business influence has inhibited both the formation of an NWP and the effective regulation of water resources according to existing laws. We also include a comparative analysis between barriers inhibiting the establishment of an NWP and those which have faced another Central American sector historically rife with human rights abuses: mining. Notably, major gains have been made with regard to the mitigation of harms enacted by the mining industry in several Central American countries, with the closing of several major mines in Guatemala, a pit-mining ban in Costa Rica, and the world's first blanket ban on metal mining in El Salvador. We identify factors which have led to the success of the mining ban in El Salvador—namely, strategic network-building on the part of anti-mining activists, the leveraging of international attention, particularly after the ICSID Pac Rim case, and the late-stage restructuring of antimining organizations—and make suggestions for their implementation with respect to the establishment of an NWP in Guatemala.

2. An NWP-Sized Hole in Existing Water Policy

Though Guatemala has not yet approved an NWP, it is far from bereft of water policies. A number of international, national, and regional regulations have been enacted since the establishment of the 1985 constitution [4,6,7]. The Constitution itself includes a number of provisions which either directly address or imply the right to safe water and sanitation [4,6–11]. Article 127 of the Guatemalan Constitution explicitly calls for the management of water resources, which are classified as a public good, through national legislation [10].

However, the current model for water regulation and management within the country is highly piecemeal, with a number of significant policy gaps and contradictory or overlapping responsibilities attributed to various agencies [12]. In particular, gaps exist in the national regulation of water, sanitation, and hygiene (WASH) services, with little common guidance for municipalities and departments, which are tasked with the regulation and provision of such services. Both central and municipal governments play a role in the construction of water management, making it difficult to assign accountability and limiting improvements, particularly for rural areas, for the sector [12].

These factors bring us to ask three essential questions: (1) What are the variables inhibiting the implementation of an NWP? (2) What factors might improve the likelihood that such a law comes into being? (3) What are the variables contributing to Guatemala's inability to effectively implement existing water laws? We argue that a democracy characterized by weak institutions and corruption expressed through the disproportionate lobbying power of the elite and business influence has strongly inhibited the formation of an NWP as well as the effective regulation of water resources according to existing laws. As evidenced by anti-mining activism in El Salvador, a strong, strategic social movement with support from citizens and international organizations across socioeconomic sectors may be key to its establishment.

3. Weak Institutions

Though Guatemala's Constitution and political institutions greatly resemble those of more equitable democracies in their formulation, the influence of relatively recent internal armed conflict and military dictatorship have profoundly shaped the social and political structure of the nation, compounding the social and political exclusion, military privilege, and lack of accountability at the heart of the country's poor water law enforcement and

lack of success in establishing an NWP [13]. Worldwide Governance Indicators (WGI) have placed Guatemala in the lowest quartile worldwide in government effectiveness, rule of law, and political stability, with only negligible improvements over the last two decades [12]. In addition, Guatemala's institutions ranked in the lowest quartile for key components of a number of indices, including political stability, conflict of interest regulation, and incidence of corruption, with the percentile ranking of institutions deteriorating for a number of indicators in recent years [8]. The country ranked in the 28th percentile in exposure to unsafe drinking water with 43% of the population exposed [8].

A major contributor to the country's inability to effectively legislate and implement water policy is its dysfunctional regulatory and management model, which leaves the country halfway between decentralized and centralized management of water services. The decentralization plan left each of Guatemala's 340 municipalities responsible for the maintenance and provision of these services with little in the way of national standards or guidelines; though the Ministry of Environment and Natural Resources (MARN) and Ministry of Health and Social Assistance (MSPAS) do set some national standards, they only partially regulate drinking water quality and wastewater treatment and discharge, and are predominantly occupied with the management of urban areas. Additionally, the decentralization plan failed to assign clear responsibility for the construction of WASH systems. While the Municipal Code establishes that municipalities are tasked with the regulation, provision, maintenance, expansion, and improvement of WASH services within their jurisdiction, they do not have the power to set national tariffs for their funding. Both the central government and municipalities spend well below the regional average for WASH services [8].

Central institutions tasked with water management have only partial responsibilities when it comes to WASH systems: where MSPAS is tasked with the issuing of regulations for the construction of WASH systems, the Municipal Development Institute (INFOM) has historically aided in the design and implementation of rural systems through the Executing Unit of the Rural Aqueducts Program (UNEPAR). Presently, UNEPAR is not allocated sufficient resources to continue in this role, and there is no coordinated supervision which ensures that standards are being met [8]. MARN and MSPAS are jointly tasked with regulating and monitoring urban water sources, but neither is clearly tasked with the monitoring of rural water resources [8]. Neither institution has the budget or capacity to effectively regulate WASH services countrywide [8].

These capacity constraints stem from a disempowered sector authority and incomplete regulation. National regulators have little power to enforce compliance among municipalities; MSPAS lacks the capacity to establish national WASH policies, enforce guidelines, or implement interventions, and the territorial coverage of MARN is insufficient to cover both rural and urban areas [8]. There are no centrally defined standards of service nor minimum levels of quality for WASH services, and municipalities are effectively left to self-regulate with minimal support from central institutions. Furthermore, the multitude of disconnected administrative units, regulators, programs, and projects creates a constraint on proper planning, budgeting, and execution of WASH-related programs [8]. In short, the design, construction, and supervision of WASH systems is not controlled by a central mandate or institution, and municipalities are not empowered to create plans or budgets which would enable their adequate planning and monitoring [8].

4. Corruption: Lobbying Power of the Elite and Foreign Business Influence

Corruption has influenced both the government's capacity to pass, and its interest in passing, an NWP [14]. Some of the most powerful pressures put on government bodies to not pass stronger laws and to not enforce existing ones come from multinational corporations (MNCs) and CACIF (Coordinating Committee of Agricultural, Commercial, Industrial, and Financial Associations)-affiliated businesses. CACIF is an employers' association made up of the Guatemalan elite with considerable political power.

The agricultural and mining sectors are two of the primary users and abusers of water resources in the region. Agriculture accounts for 13.5% of Guatemala's GDP and employs 31% of the labor force [15] and is dominated by fruit MNCs Dole, Chiquita, and Del Monte [16]. The agricultural sector used 60% of water resources in 2010, marking a 6322 million m^3 increase over 10 years, despite a 0.7% decrease in GDP contributions over the same period (from 9.7% to 9%) [17]. Agricultural MNCs have a large financial stake in the continued abuse of water resources and neo-liberal interpretation of water-related legislation. The permitting of re-routing waterways on privately owned land even to the detriment of those downstream is a clear case in which private land rights have functionally superseded the constitutional claim to water as a universal good [18]. In addition, MNCs benefit greatly from the fact that free-flowing water (i.e., flowing directly from rivers or otherwise unpiped) is unlikely to be measured or charged for. Of all the water flowing through the economy in 2010, only 1.2% was distributed through managed systems and capitalized upon, marking an extreme loss of potential revenue to empower municipalities and central institutions [17].

Not only is agriculture the sector with the highest raw water inputs, but it also contributes substantially to water pollution in the country. Large monoculture crops, such as banana, sugarcane, and oil palm, are heavy users of inputs such as fertilizers and pesticides, which make their way into rivers and can drain into lakes. Studies of the lake Atitlan, for example, have demonstrated a direct negative correlation between lake water quality and agrochemical runoff, which has contributed to mass fish death events and eutrophication [18].

Though the use of water in mining pales in comparison to agriculture [17], it is not insignificant; for example, the leaching process at Guatemala's Marlin I mine required 250,000 per hour [19], or over 8000 times the average daily water use of a family in that region. Mining is also a significant polluter; gold mining, for example, requires that ore be treated with a mix of water, lime, and sodium cyanide, and drainage of acid contaminates local waters with heavy metals [19]. Much like agriculture, the mining industry makes up only a tiny fraction of the country's GDP, though it is a major international moneymaker [20]. Additionally, many jobs produced by the industry are not given to locals, but to foreign specialists [20–22].

Corruption in the global mining industry and in the Guatemalan state have been well-documented, with mining recognized as the sector fourth-most susceptible to corruption (behind construction, utilities, and real estate), and frequent corruption scandals shaking the Guatemalan state [15,22,23]. Corruption, as it relates to water resource management, can be found particularly in key moments of environmental governance, such as the approval of environmental impact assessments (EIAs) [22]. Bribery of and threats toward state officials tasked with approving and reviewing production licenses are commonplace, and the stance of the Presidential administration is likely to determine the speed with which an EIA is approved. This 'top-down' approach to EIA approval has resulted in the shuffling of at least one uncooperative official away from a position with the power to approve mining licenses [22].

Finally, corruption can be found in CACIF (Coordinating Committee of Agricultural, Commercial, Industrial, and Financial Associations). CACIF is an employers' association with considerable political power, as it unites the country's most important economic actors. Its members, the traditional and emerging economic elites of the country, finance political campaigns and subsidize the income of ministers through bonuses known as "dobletes", which are in some cases paid directly by large corporations [15]. Notably, once the CICIG, the International Commission against Impunity in Guatemala founded in 2006, began to investigate illegal campaign financing in 2016, sixteen CACIF members found themselves implicated in criminal activity, and a CACIF-funded group paid US lobbyists in an effort to repeal the CICIG mandate [24]. Then-president Jimmy Morales (2016–2020) and several other political figures were targeted, causing Morales to end CICIG's mandate and fire several reformist officials, all while pushing for legislation which would provide amnesty

to "perpetrators of crimes against humanity" [25], free several prisoners held for corruption, and limit the non-government organization involvement [25].

5. Lessons from El Salvador

Now, we turn to El Salvador's long transition from a largely deregulated mining industry to an outright ban on metal mining, with the hope of producing some insight into potential strategies for Guatemala and the effort to establish an NWP. There are two significant similarities between the cases: first, the establishment of an NWP and that of restrictive mining legislation are both inextricably woven into concerns regarding the human right to an adequate quantity and quality of water. As noted above, one major polluter of water resources in Guatemala is the mining industry. The protection of water resources was also galvanizing concern for Salvadoran antimining activists. Restrictive mining laws contribute to improvements in water quality, at a minimum by minimizing pollution, though also potentially by reducing pressures on limited water resources.

Second, both countries have struggled with weak democracies characterized by corruption and international pressure to permit the exploitation of natural resources. El Salvador and Guatemala's paths to democracy, though far from identical, share some common features: a long civil war, waged between a military-led junta and leftist groups, that began with an internationally backed coup d'état and ended with the establishment of a weak democracy marked by a dominant, right-wing, military-backed party keen on cementing the interests of a transnational economic elite through neoliberal political reformation. This led to widespread deregulation and the promotion of foreign investment through tax exemptions and legal protections for foreign investors [26].

Business elites and MNCs have shaped (and continue to shape) the political trajectories of both countries through business associations, political parties, and think tanks. Furthermore, gaps between the poor and nonpoor are large in both countries: the poor are more likely to live in rural areas, belong to Indigenous groups, and have access to very little social and political capital [27–29].

6. El Salvador's Anti-Mining Mobilization

After years of mass displacement as a consequence of the civil war, many Salvadorans returned to the regions which they had fled, forming local and regional associations to represent the interests of those living in these newly resettled areas. The anti-mining movement began through the coalescence of a number of such organizations under the national umbrella of CRIPDES (Association of Rural Communities for the Development of El Salvador), with The National Round Table Against Metal Mining (Mesa) formally launching in 2005.

The mining debate first made it onto the policy agenda in 2006 but was stymied by counterpressure through corporate manipulation of domestic political processes, corporate leveraging of the international ICSID process, and the generally neo-liberal post-war political environment marked by deregulation. The switch from a generally pro-mining government to the passage of a unanimously supported anti-mining law in congress was a function of both a long-run campaign and the specifics of the moment [28].

Though the variables impacting the passage of the antimining bill are many, several key factors are worth noting. In particular, the ongoing efforts of a well-organized anti-mining movement, the deleveraging of external pressure, and the restructuring of anti-mining leadership contributed to the final decision to ban mining twelve years after the first regulatory policy was proposed [28].

The causal mechanisms underpinning the movement-policy nexus (i.e., the effects of social movements on policy changes) are notoriously difficult to pin down [28]. However, the prolonged struggle against mining in El Salvador presents a unique opportunity for a 'slow movement analysis,' or the long-form tracing of strategic action and decision-making, which in turn facilitates the development of better causal relationships between

specific movement strategies and developments in both public opinion and policy development [28].

The Mesa movement had several key successes in its network-building. Activists strategically cultivated 'weak' or 'bridging' ties between groups with varied cultural and social backgrounds. This enabled community members to contribute local knowledge, while national allies provided familiarity with decision-making processes and proximity to decision-making centers [28]. Though these types of ties are frequently accompanied by social friction and mutual mistrust (in contrast to 'strong' or 'bonding' ties, which are founded on mutual experience and a shared culture), they promote multisectorialism and accelerate the diffusion of information. In this way, the strategic linking of those most vulnerable and those closest to decision-making centers created the potential for not only the humanization of hardships faced by those affected by mining, but also the development of a robust network of sympathizers across the spectrum of political power. Mesa also adopted a policy of "hablar sin hablar" or communicating while avoiding making statements that would "invite rejection and retaliation" [28] and centered cultural and artistic activities in its protest style. For example, a major rally was strategically called the "Caminata verde en defensa del agua" instead of a "marcha", "protesta", or other more polarizing term [28]. This kind of language made the movement more palatable to a greater number of people, serving 'bridging' relationships and encouraging multisectorialism.

In addition to the strategic networking of Mesa, community-level organizers also encouraged and engaged in resistance against neoliberalism through traditionalism: potentially mineral-rich land was purchased to be converted to places of worship, and strong bonds with Catholic and Episcopal leadership were forged, with the Conferencia Episcopal de El Salvador (CEDES) and the Catholic Church of El Salvador issuing a joint statement calling for the denial of new metal mining permits and a formal statement against mining, respectively [30]. Alternative options for economic empowerment through traditional microenterprises, such as fishing and the preparation of nuts for export, were encouraged in mining communities [29].

These long-form strategies worked to slowly change prevailing opinions regarding the safety and sustainability of mining in El Salvador: where 62.5% of Salvadorans responded 'no' when asked if El Salvador was a suitable country for mining operations in 2008, 79.5% gave the same response by 2015 [30]. Pro-mining became a less viable political stance as the business sector that had initially supported mine development lost its broad elite backing, so much so that the fourth ARENA president, Antonio Saca (2004–2009), shifted his position in defiance of Pacific Rim's threat to file a claim despite the party's long-standing support of mining MNCs [28].

In addition to this slow shift in public opinion as a result of anti-mining activism, two key variables rapidly changed the political viability of a mining ban: the outcome of the ICSID case filed by Canadian mining corporation Pacific Rim, and a restructuring of the hierarchy in Mesa to favor Church leadership.

The lawsuit filed by Pacific Rim played a critical role in both the delay and final passage of the mining ban in El Salvador. The case was filed in 2008, a year after President Saca announced a moratorium on new mining concessions following a study that demonstrated high levels of cyanide and sulfur leaching from a long-closed mine into the San Sebastian River [30]. Pacific Rim sued El Salvador on the grounds that the moratorium violated the Central American Free Trade Agreement (CAFTA), ultimately seeking damages for $314 million in losses of potential profit [31]. This claim and its dismissal were catalysts for the final decision to ban mining outright. After facing the threat of either a crippling payout or the internationally forced authorization of a mining concession, legislators became acutely aware of the vulnerability of their position: though Pacific Rim had failed to wrest hundreds of millions of dollars from the country as lost 'potential profit,' any American mining firm displeased with the country's future mining decisions could very well file similar, if not more compelling, cases. El Salvador needed to act quickly: it did not have

the resources to fight more lawsuits in international court, nor did it have the capacity to manage the environmental risks associated with mining [28].

After the Pacific Rim case came to an end, collaborations between the Catholic Church and Mesa shifted to center the role of the Church. This shift worked in favor of mining activism in several ways: first, it served to ease the "partisan identity of the cause" [30], allowing a new proposal, written in collaboration between the Church, the Jesuit Universidad Centroamericana (UCA), and policy strategists, to be presented with pre-established support from Archbishop Escobar Alas and several legislative leaders [28,32]. The centering of the Church in politics was not without its critics, but the bad press mining had received, coupled with the rallying of international support after the Pacific Rim case, could not be denied. The bill was quickly and unanimously approved by legislators in attendance [28,33].

7. Opportunities for Guatemala

We return to the case for an NWP in Guatemala with the following question: what can be learned from El Salvador's long struggle toward a mining ban? To begin, the political landscape surrounding the delayed establishment of an NWP in Guatemala appears substantially different from that of the mining ban in El Salvador; where the Salvadoran political landscape was dominated by two parties (the leftist FMNL and right-wing ARENA), reinforcing polarization and social movement partyism on the topic of mining, Guatemala has a multitude of relatively unstable parties, none of which have won more than one presidential election [34]. However, it is worth noting that CACIF has remained a stable right-wing political actor, operating as the "de facto political party of Guatemala's economic elites" [14] and influencing the path of Guatemalan politics toward neo-liberalism and deregulation for decades [15]. Proponents of neo-liberal policy have a significant advantage in that they have already coalesced into a unified front, where leftist organizations are scattered and disorganized. Protests against the abuse of water resources in Guatemala are far from uncommon, with at least tens of organizations organizing marches and protests for water at one point or another; however, these organizations lack the scrupulous strategy of Mesa and stability of CACIF, undermining their effectiveness.

Fortunately, there is evidence that Guatemalan people are not so polarized that they cannot bridge differences and unite through trust in a common organization; that evidence is to be found in the overwhelming popularity of CICIG [35]. Though the mandate was not renewed after it began investigating the sitting President and his inner circle, its popularity with the people hints at the possibilities for a future nonpartisan organization to gain widespread approval and effect real political change. Furthermore, the two countries share some broad cultural similarities: strong Catholic and Protestant communities with prominent, high-ranking figures aligned with the efforts to establish an NWP [36]. Strong traditionalist values, like those leveraged by Mesa to encourage alternative micro-enterprise in mining communities, could likewise be leveraged in Guatemala, particularly for the large swaths of people working in agriculture, as well as the smaller groups in mining towns.

The outcome of the Pacific Rim ICSID case is also of no small relevance, as Guatemala is another CAFTA member country likely to be targeted by MNCs were it to deny them the right to the exploitation of its water resources. The current neoliberal interpretation of private land rights to water relies heavily on the absence of a national mandate asserting the constitutional right of the people to clean, readily available water. Though the establishment of an NWP may trigger lawsuits in international courts, MNCs' reliance on an interpretation of private land right laws which directly contradicts existing constitutional mandates regarding both the right to and use of water leaves the outcome of such lawsuits uncertain. The precedent set by the Pacific Rim case should not be ignored.

One significant difference between the two cases must be admitted: the 2008 mining permitting freeze in El Salvador stemmed in part from a recognition of the state's limited capacity to adequately enforce mining regulation. There is no parallel for Guatemala here; indeed, a similar concern may be used to argue against the development of an NWP

for the country. Establishing and regulating WASH services would require significant state resources and a shuffling of priorities given the limits of those resources. Finally, it must be noted that the institution of an NWP for Guatemala is a far cry from a guarantee of access to WASH services for all citizens. The variables inhibiting the establishment of such a law—particularly weak institutions and corruption—are likely to persist even after its establishment, and the difficult tasks of rooting out corruption and strengthening institutions will still need to be done. However, an NWP—depending on its contents—could work to improve the strength of both central and municipal institutions tasked with providing WASH services, and the powerful message such a move could bring should not be discounted.

In sum, we have argued that a democracy characterized by weak institutions, corruption, and international business influence has inhibited both the formation of an NWP and the effective regulation of water resources according to existing laws in Guatemala. We then brought our attention to key factors which led to the success of El Salvador's mining ban—strategic network-building by activists, the deleveraging of international pressure, and the late-stage restructuring of anti-mining organizations—after which we sketched some suggestions for their relevance to the NWP case in Guatemala. Finally, we noted that even the successful establishment of an NWP, though a powerful message regarding the priorities and power of the Guatemalan people, is likely to amount to little more than a first step in an extended struggle to secure adequate WASH services in Guatemala.

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Proceeding Paper

How NorDan AB Applies the UN SDGs in a Pragmatic Way and Contributes to a More Sustainable Scandinavian Building Industry †

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Abstract: NorDan AB in Sweden has, over the last years, actively used the UN Sustainable Development Goals (SDGs) as part of its strategy for sustainable development. The company has focused on selected SDGs and carried out a high number of improvements and innovations within additive manufacturing. Furthermore, it has actively applied the Swedish business excellence model, the SIQ Management Model, to assess its current sustainability status, identify areas for improvement, and develop in a systematic and sustainable way. Today, the company and its product offering have a clear sustainability profile, recognised by many customers and stakeholders within the industry.

Keywords: sustainability; UN Sustainable Development Goals; quality management; business excellence models; SIQ Management Model; additive manufacturing; windows and doors; building industry; Scandinavia

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1. Introduction

NorDan AB in Sweden is one of the leading window and door manufacturers in the Swedish building industry. The company has 350 employees, with three factories and five sales offices. It is a subsidiary of the NorDan Group, a family-owned company based in Norway with operations in 10 countries.

Since 2018, NorDan AB in Sweden (hereinafter NorDan) has worked on a holistic strategy focusing on sustainability, quality management and profitable growth. On the sustainability agenda, the company committed itself to working on the UN Sustainable Development Goals (hereinafter SDGs). It selected 7 of the 17 goals based on relevance to NorDan. Goal 8 and Goal 11 to address local values, Goal 3 and Goal 5 to focus on people, Goal 9 and Goal 12 to reduce consumption of resources as well as Goal 17 to involve customers and stakeholders in this important work. Throughout, NorDan has maintained a very practical and pragmatic approach toward sustainable development, focusing on improvements, innovations and working methods that make a positive contribution to a more sustainable company and product offering. It has also been driven by the wish to be at the forefront of sustainability developments within the Scandinavian building industry, and in many ways, to be a leading company within this area.

This paper discusses the strategic and operational approach that NorDan has taken to sustainability and how this, in a genuine and credible way, has given NorDan a clear sustainability profile. First, this paper presents how the strategic approach, including the SDGs, has helped NorDan become more sustainable. Second, NorDan's approach to business excellence is described and how the SIQ Management Model has provided a useful framework for the company's sustainability journey. Third, NorDan's innovations in additive manufacturing and its connections to the SDGs are presented. The paper ends with some general takeaways from NorDan's sustainability journey so far and reflections on future developments.

2. Strategic Approach to Sustainability

NorDan was first introduced to the concept of "Sustainability" by the company's largest customer, NCC Construction Sweden AB (hereinafter NCC), at NCC's sustainability supplier conference in April 2015. Here, NCC's approach to sustainability was explained, together with a set of expectations for its supplier. As part of the presentation, sustainability was defined and presented to the participating suppliers, with reference to the Our Common Future report from 1987 by the World Commission on Environment and Development [1] and the three pillars of sustainability: social, economic and environmental [2,3]. NCC was very clear on its strategic approach to sustainability and how it relied on suppliers to establish transparent supply chains and contribute to NCC's goals for more sustainable buildings and cities. As a strategic supplier to NCC, NorDan started exploring theories, models and approaches to sustainability and how it was different and broader than the company's current focus on the environment and its current systems for health, safety and environment (HSE).

In September 2015, the 17 Sustainable Development Goals (SDGs) were set by the international community as part of the UN 2030 Agenda for Sustainable Development [4]. The Swedish government, with PM Stefan Löfven, took an active approach to embrace and support the SDGs [5] and showed a clear determination to get companies involved and accountable [6]. In 2016, the Swedish Government enacted a new law that made it mandatory for companies with more than 250 employees, from the fiscal year 2017, to publish a sustainability and equality report, either separately or as part of the annual financial report [7]. This development was also related to the global reporting initiative (hereinafter GRI) that, in 2016, provided the first global standards for sustainability reporting, the GRI Standards [8].

NorDan was inspired by the clear trend among customers to focus on sustainability as well as the strong political agenda for sustainability in Sweden. During the autumn of 2016, the management team started preparing NorDan´s first sustainability and equality report in accordance with the new regulations. In many areas of sustainability, NorDan already had good practices and working routines and systems due to the company's historical development and product offering, as well as a clearly documented quality management system based on ISO 9001 [9] and environmental management system based on ISO 14001 [10]. Furthermore, the company had worked for more than 5 years with lean production [11] through the company's "NorDan Production System". The analysis and documentation of the first sustainability and equality report made it clear to the management team of NorDan that whereas the environmental and economic pillars of sustainability were covered in a good way, the social pillar was rather weak.

In 2017, NorDan became a member of The Swedish Institute for Quality (hereinafter SIQ), the leading national centre for business excellence in Sweden [12]. At that time, SIQ had conducted a major update and revision of its excellence model, the SIQ Management Model, and NorDan accepted the invitation to be one out of five pilot companies to test the new model [13]. The most significant update to the model was that sustainability, with its three pillars, was fully incorporated. The self-assessment by the NorDan management team towards the criteria of the SIQ Management Model, as well as feedback from SIQ's auditing team, revealed that the main improvement areas for NorDan were social sustainability, digitalisation and innovation.

During the autumn of 2017, NorDan decided to build on the valuable input from customers, government and SIQ about the main improvement areas. Hence, NorDan embarked on a journey to become excellent in all three pillars of sustainability and be one of the leading companies in the Scandinavian building industry in sustainability and digitalisation. In 2018, NorDan introduced a new company strategy with three main elements: (1) sustainability, (2) quality management and (3) profitable growth. It also launched the *ecoDigital ready*™ initiative at Nordbygg 2018, the bi-annual trade show in the Swedish building industry. *ecoDigital ready*™ highlighted the company's commitment to sustainability and digitalisation, with a clear outline of activities and customer promises.

The focus of NorDan was to change the way the company worked to truly become more sustainable and digitally mature, and to be at the forefront of these developments within the Scandinavian building industry. The management team also realised that the changes needed to be visible, both internally to employees and externally to customers, suppliers and other stakeholders. A lot of planning work was conducted to map the current strengths in order to capitalise on these moving forward and to identify additional improvements, innovations and changes necessary. Out of this strategic planning process, a range of development areas were identified and initiated, including:

- Organise with a clear focus on sustainability and digitalisation;
- Explore opportunities within additive manufacturing and modern materials;
- Look at sponsorship opportunities with a clear social responsibility profile;
- Evaluate potential of new business models in a circular economy;
- Deliver digital solutions to the customers and the market;
- Increase digital maturity level in all key processes;
- Communicate the strategy and achievements to the market;
- Reduce CO_2 footprint of operations.

NorDan did not set a specific goal for CO_2 reduction at this early stage in the strategy. Instead, it realised that it was important to link the strategy and the many initiatives to the SDGs. The management team selected 7 out of the 17 goals that were most relevant to the business idea of NorDan: Goal 8 (Decent Work and Economic Growth) and Goal 11 (Sustainable Cities and Communities) under the heading "Local values", Goal 3 (Good Health and Well-Being) and Goal 5 (Gender Equality) under the heading "People" and Goal 9 (Industry, Innovation and Infrastructure) and Goal 12 (Responsible Consumption and Production) under the heading "Reduce consumption of resources". The company also decided on Goal 17 (Partnerships for the Goals) to actively involve suppliers, customers, universities and industry networks to enhance developments and innovations. The company posted the commitment to work on the SDGs on its homepage [14] and made reference to the SDGs in internal and external communication.

Over the years, NorDan has been committed to this practical and pragmatic approach toward sustainable development, focusing on projects that make a positive contribution to a more sustainable company and product offering. Examples of successful projects and initiatives are:

- Introducing 3D printed windows in bio-composite materials;
- Launching advanced environmental product declarations;
- Becoming a sustainability partner to Save the Children, Sweden;
- Developing a solution for recycling used windows and doors;
- Publishing numerous Building Information Modelling (BIM) models of products and developing a solution for the digital generation of quotations;
- Sourcing green electricity;
- Launching a digital showroom, including presentation of the SDGs;
- Installing solar-PV plants at all three factories in Sweden.

As the company prepares for the strategic period 2022–2024, it continues its focus on sustainability and the SDGs. Social, economic and environmental sustainability can always be improved and further developed. Three main work areas that the management team has identified for the next years are: (1) achieve carbon neutrality by 2025, (2) maintain a strong sustainability profile within the Scandinavian building industry and (3) continue to embrace, learn from and adopt new developments within sustainability and digitalisation in an agile way.

3. Business Excellence Models

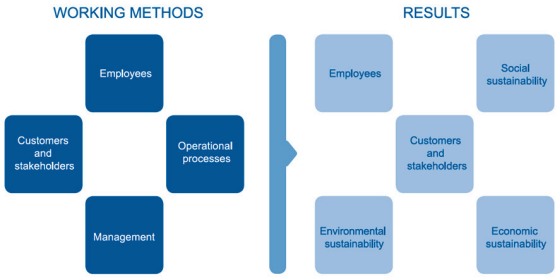
Interestingly, both the Our Common Future report by the World Commission on Environment and Development [1] and the Malcolm Baldrige National Quality Award [15] were introduced in 1987. The Baldrige Award, based on the Baldrige Excellence Framework,

was the first business excellence model and national quality award in the western world, and it was inspired by the Japanese Deming Price ([16], pp. 70–71). In Europe, the EFQM Excellence Award, based on the EFQM Excellence Model, and the Swedish Quality Award, based on the SIQ Management Model, were both introduced in 1992, and from then on, many other countries have launched their own business excellence models and quality awards [17].

Business excellence models are commonly regarded, in both industry and academia, as holistic and advanced management models that develop in accordance with leading management theory and can be applied by organisations across all industries and sectors ([16], pp. 99–124, [18,19]). The purpose of these excellence models and the quality awards are twofold: (1) to provide a framework and model for business excellence that companies can use for self-assessment and (2) to recognise excellent organisations at a national level and share best practices [20]. Analysing these business excellence models in the mid-1990s, the author of this paper found that it was possible to extract eight common criteria across the different national quality award models at that time: (1) Leadership, (2) Impact on Society, (3) Information and Analysis, (4) Strategic Planning, (5) Human Resource Management, (6) Processes, (7) Customer Focus and (8) Business Results [21]. From a sustainability point of view, it can be interpreted that social and environmental sustainability are parts of "Impact on Society", whereas economic sustainability is covered in "Business Results". However, no clear reference was made in these excellence models to sustainability, as defined in the Our Common Future report from 1987, nor the three pillars of sustainability.

From 2015 to 2017, SIQ worked on a major revision of the Swedish business excellence model. One of the most notable changes was the integration of all three pillars of sustainability—social, economic and environmental. With the publication of the updated SIQ Management Model in 2018, sustainability is clearly visible in the results criteria and also in the working methods [13], Figure 1. The SIQ Management Model gives a detailed description of the criteria and sub-criteria in the model, including what is expected of excellent organisations. Organisations applying the model must complete a self-assessment with regards to current approaches in all criteria and also describe how it continuously improves, learns and develops within these criteria. This means that companies working with the SIQ Management Model actively address all three pillars of sustainability and develop these through continuous improvements and innovations. As part of the revised SIQ Management Model, the Swedish Quality Award logotype was also updated with a new headline, namely "Sustainable Success".

For the management team at NorDan, it has been very important to use the SIQ Management Model as a framework to assess the current sustainability status, identify areas for improvement, and develop in a systematic and sustainable way. The SIQ Management Model has directed NorDan to the areas within sustainability where it already has systematic working methods and achieves good results, but also to areas where it needs to improve and develop. It has also been important to understand that in order to improve the result criteria of the SIQ Management Model, the company needs to focus more on the working methods by carrying out improvement projects and innovations.



(**a**)

1	CUSTOMERS AND STAKEHOLDERS	150
1.1.	Understand the needs and expectations of customers and stakeholders	50
1.2	Create value with customers and stakeholders	50
1.3.	Create promises to customers and stakeholders	20
1.4.	Follow up the level of satisfaction among customers and stakeholders	30
2	MANAGEMENT	125
2.1	Plan for a sustainable organisation	30
2.2	Lead the organisation for sustainability	40
2.3	Lead coworkers	30
2.4	Lead processes	25
3	COWORKERS	125
3.1	Develop coworker skills	40
3.2	Promote creativity and participation	45
3.3	Follow up coworker satisfaction and develop a good work environment	40
4	OPERATIONAL PROCESSES	100
4.1	Establish processes	30
4.2	Improve processes	70
5	RESULTS	500
5.1	Results - Customers and stakeholders	100
5.2	Results - Coworkers	100
5.3	Results - Social sustainability	100
5.4	Results - Environmental sustainability	100
5.5	Results - Financial sustainability	100
TOTAL POINTS		1 000

(**b**)

Figure 1. The SIQ Management Model for sustainable success [13]. (**a**) The structure of the model, with four main areas for working methods and five result dimensions. (**b**) The five criteria each hold sub-criteria, each with a weighting in terms of how many points are possible to score. Models used with permission of the Swedish Institute of Quality, SIQ.

4. Innovations in Additive Manufacturing

NorDan has gained significant international attention and recognition for its pioneering efforts in 3D printing, in which the company—in good cooperation with key suppliers—developed a production technique, material solution, product documentation and marketing concept for commercial sales of 3D printed windows in bio-composite materials. The product was launched in the Scandinavian market in October 2019 as the world's first 3D printed window for commercial sales [22].

The 3D printer project was one of the first large projects that NorDan initiated in the autumn of 2017 when it decided to become one of the leading companies in the Scandinavian building industry in the areas of sustainability and digitalisation. From the very start, the 3D printer project was driven by a clear overall goal, i.e., to be the first company in the world to start sales of 3D printed windows.

When searching for manufacturers of 3D printers—large enough to print full-sized windows and doors for NorDan—the options were very few in 2017. After some months, NorDan got in touch with a Swedish start-up company with interesting prototype technology for large 3D printers. The company, BLB Industries AB, designed a unique large-scale 3D printer for NorDan, which could print windows and doors up to 1.5 m in width and 2.5 m in height. NorDan decided to make the investment, and the 3D printer was delivered in 2018 (Figure 2). The 3D printer uses granular materials for printing, which is much more affordable and industrially viable for large-scale commercial 3D printing compared to expensive filament material.

During the innovation project, NorDan explored many options for printing materials, which included the likes of acrylonitrile butadiene styrene (ABS) and polypropylene (PP). If NorDan had decided to continue with those readily available materials in the market, the project would have been completed much earlier. However, NorDan's focus on sustainability directed the innovation project to focus on finding the most sustainable material possible so that the 3D-printed windows would contribute to the SDGs (in particular Goal 9 and Goal 12) and remain in alignment with the other products in NorDan's timber range. Because of this, the company decided to work with Stora Enso for material testing and development of a bio-composite granular material (Figure 3), aiming to achieve a high wood content and excellent recycling properties. Stora Enso's competence centre and factory for bio-composites are located in Smaaland, Sweden, in the same region as NorDan's factory

for entrance doors and BLB Industries. A unique innovation project cooperation between NorDan, BLB Industries and Stora Enso was established, and Goal 17 (Partnerships for the Goals) was clearly evident throughout the project.

(**a**) (**b**)

Figure 2. The unique large-scale 3D printer at NorDan. (**a**) The printer is placed in the main assembly area of NorDan's factory for entrance doors in Bor, Sweden. (**b**) The 3D printer is operated by qualified employees.

(**a**) (**b**)

Figure 3. Printing material, i.e., granular bio-composite material and commercial window product. (**a**) Granular materials in bio-composites are used as raw material in the 3D printing process of NorDan. Bio-composite consists of wood fibres and polymers [23]. (**b**) An example of a 3D-printed window from NorDan, circular window where the frame has been manufactured in NorDan's 3D printer.

To ensure that the performance of the 3D printed windows in a building façade was maintained, product tests were performed at the Research Institutes of Sweden (RISE), using the same testing parameters as practised with traditionally manufactured windows in timber. The test results were very good, and the 3D printed windows were granted approval. The first products to be 3D printed were shaped windows (e.g., circular and half-circular), as these are amongst the most expensive and difficult to produce within the window industry. NorDan's innovation in 3D printing had very visible success in terms of digitalisation (additive manufacturing), sustainability (material and recycling properties) and effectiveness (reduced lead times, cycle times and costs).

NorDan has received much media attention and has been awarded international prices for 3D-printed windows in bio-composites, including the Quality Innovation Award

2019 [24], the Quality Sustainability Award 2020 [25] and the Most Sustainable Product 2020 on BIMobject. The company continues to explore the possibilities within additive manufacturing and the application of bio-composite materials. It is currently working on the high-volume production of profiles for windows and doors in bio-composites, including the use of recycled plastics in the composite fraction. In addition, additive manufacturing has the potential to enable flexible production closer to the end-market and construction sites. Furthermore, given that the technology is based on additive manufacturing using bio-composite material, it opens for sustainable production of many kinds of products within the building industry and beyond. Recently NorDan has been invited to deliver 3D printed windows and doors to the first 3D printed house in Sweden [26].

5. Lead by Example and Dare to Share

Very often, it is the large enterprises within an industry that have the resources, initiatives and strategies in place to credibly claim they are working with sustainability in a strategic way and make a positive impact. NorDan is a small and medium-sized enterprise (SME) with 350 employees, which normally should not have a big impact nor get any attention. However, NorDan decided early to "lead by example" and to "dare to share" in the area of sustainability. It is also how the management of NorDan has understood the UN's work on the SDGs, Agenda 2030 and carbon neutrality by 2050, namely that everyone can and must contribute at a national, regional and local level for the joint efforts of nations, governments, businesses and individuals to be successful [27].

The strategic focus on sustainability by NorDan has made the company better and more mindful. With the many successfully completed projects within sustainability, NorDan has, for some time, been able to communicate its work on sustainability and the SDGs in a credible way to the market. Some examples are 3D printed products in modern biomaterial, solar PV plants at factories, sustainability partner for Save the Children Sweden and reduced CO_2 footprint. This credibility is very important and works in a self-enforcing loop as more projects are added and new levels of development within sustainability are reached. It also gives NorDan a competitive advantage in the market, as the company is regarded to be working very well with sustainability. NorDan applies both standard project methods and more agile ways of working to achieve improvements and innovations, depending on the nature of the project and the complexity.

Customers, suppliers and other stakeholders frequently give positive feedback to NorDan about its progress in, and focus on, sustainability. The company views this as good recognition of the work done so far and also as an inspiration to continue on the sustainability journey. In May 2021, the Swedish Federation of Wood and Furniture Industry—Trä- och Möbelföretagen (TMF), put sustainable development on the agenda when it published a guideline document for all members [28]. TMF is the national trade and employers' association of the wood processing and furniture industry in Sweden, representing some 700 member companies and more than 30,000 employees. This development is welcomed by NorDan and shows that the Swedish building industry is starting to join forces to make progress towards a circular and sustainable building industry.

Management representatives from NorDan have also actively taken board member positions in industry networks which focus on one or more sustainability aspects both within the building industry and across industries. In this way, the company is involved in development trends and can directly enhance sustainability topics and put them on the agenda. NorDan is also working actively with academia and research institutions. In 2021, the company is involved in two large applications for funding research projects on sustainable development together with leading Swedish universities. The progress of NorDan within sustainability has also inspired other NorDan subsidiaries to work on the SDGs, and the *ecoDigital ready*™ initiative has been adopted by all subsidiaries [29].

Overall, the development within NorDan described above is very much in line with the reasoning and developments described within "Quality 5.0" [30], where the purpose of

organisations is firstly to focus on customers and stakeholders but also at the same time support development and societal satisfaction and contribution.

6. Conclusions

Over the last five years, NorDan has worked actively with sustainability at a strategic and operational level. The company has focused on the UN SDGs and on running improvement projects to enhance sustainable development in a pragmatic, collaborative and project-driven way. It discovered the advantages of linking sustainability and digitalisation in some areas and how these two mega trends complement each other well. Furthermore, in order to change quickly enough and make breakthrough improvements, it is necessary to also focus on innovations and work in agile ways.

The SDGs and the SIQ Management Model have been very helpful for NorDan in its sustainable development journey so far. The SIQ Management Model fully incorporates all three pillars of sustainability and offers organisations a strong and practical framework to assess current status in sustainability, identify areas for improvement and develop in a systematic and sustainable way. More research and work should be directed into how business excellence models around the world can more clearly encompass sustainability and the three pillars of sustainability, thereby supporting more organisations on their sustainable development journey.

The work on sustainability by NorDan has already changed the company for the better and reduced its CO_2 footprint. Furthermore, it has formed the basis and inspiration for continued work on sustainability and the SDGs in the years to come.

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Proceeding Paper

Digital Finance in Africa: Accelerating Foundations for Inclusive and Sustainable Local Innovation †

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Abstract: Research has shown that the digital finance transformation has a significant impact on supporting multiple SDG goals. These effects are especially profound within geographic areas where traditional banking infrastructure has historically remained under-developed, including Sub-Saharan Africa. Innovations in digital financial technologies create opportunities to connect people, communities, and organizations without traditional banking infrastructure, bypassing physical geographic restrictions through using the internet and mobile networks. In this study, we thus seek to identify existing gaps in support necessary for stakeholders within an African context to engage with developing digital financial tools in an inclusive, resilient, and sustainable manner.

Keywords: digital finance; sustainable development; Africa; innovation; digital ecosystem; data economy

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1. Introduction

Digital finance is described as the "impact of new technologies on the financial services industry… [resulting in] a variety of products, applications, processes and business models that have transformed the traditional way of providing banking and financial services" [1]. Prior research has shown that this transformation has a significant impact on supporting multiple UN Sustainable Development (SDG) goals, including gender equality (SDG 5), decent work and economic growth (SDG 8), and reducing inequalities (SDG 10) (UNDP, 2020). These effects are especially profound in geographic areas where traditional banking infrastructure has historically remained under-developed, including Sub-Saharan Africa. Innovations in digital financial technologies create opportunities to connect people, communities, and organizations without traditional banking infrastructure, bypassing physical geographic restrictions by using internet access and mobile networks. Financial services critical for the support of SDGs can thus be offered at a distance with tools as simple as a Nokia mobile phone. The recent COVID-19 pandemic has further accelerated awareness of the need for regional ecosystems to develop capacity in sustainably creating and implementing such digital innovations at a local level to address evolving local needs.

In this study, we sought to identify existing gaps in support necessary for stakeholders within an African context to engage with developing digital financial tools in an inclusive, resilient, and sustainable manner. The results of these analyses are presented in this paper. We believe that the recommendations identified may help local industry leaders,

policymakers, and entrepreneurs to leverage the strengths of digital finance as a catalyst for increasing inclusive and sustainable local innovation across the African continent while still remaining aware of its limitations as a tool.

2. Materials and Methods

The authors analyzed the current state of local and regional digital innovation in the financial landscape across Africa through a mixed-methods approach. First, we reviewed equity funding data within the African digital financial services sector to identify trends in the current digital innovation ecosystem, extending beyond the common focus of mobile money payment systems (70% of current funding) to include financing services (6% of total funding), investing services (3% of total funding), and supporting digital financial services (22% of total funding). This data was supplemented by 27 informational interviews with regional and sector experts, including managing and regional directors of incumbent companies in the financial and telco sectors, local Fintech entrepreneurs, regulators and government officials, and investors. Based on these interviews, we conducted a third analysis mapping the current regulatory landscape at a national level to determine current barriers and enablers to further local-level growth and innovation within the digital finance sector.

Additionally, the core research for this study was conducted over the summer of 2020 during the initial outbreak of the COVID-19 pandemic. The authors were constrained by the geographical limitations posed by rolling national and international lockdowns and thus conducted all interviews, literature reviews, and database analyses virtually.

2.1. Databases

2.1.1. Crunchbase

Business information platform Crunchbase was used to source equity funding information on startups as well as privately and publicly held companies operating within the African Fintech space. While considered a standard resource for investment and academic research on startups, we are aware that there are missing data and limitations on the accuracy of crowdsourced data [2].

2.1.2. GSMA Mobile Money Deployment Tracker

The authors used the GSMA Mobile Money Deployment Tracker to build a picture of the geographical distribution of mobile money and digital finance across African countries, as well as to obtain a list of international technological actors and partnerships. The Deployment Tracker monitors global mobile money services through a combination of primary and secondary sources collected monthly. This database allowed us to follow live services in each African country, including their launch year, the range of mobile money products provided (e.g., peer-to-peer transfers, bill payments, airtime top-up, etc.), and to map out relevant partnerships with banks and technological actors. These data were invaluable in building a solid overview of the number and origin of mobile money actors across regions and countries of Africa, as well as in understanding the penetration of global technological actors within each market (e.g., Huawei's technological partnerships with TNM and M-Pesa, respectively, in Malawi, DRC, and Mozambique, among others).

2.1.3. GSMA Mobile Money Regulatory Index

The GSMA Mobile Money Regulatory Index was used to identify regulatory systems across Sub-Saharan Africa. The GSMA MMRI is a single composite indicator used to measure how enabling a county's regulatory approach is. It follows 26 indicators across 6 main categories that rank systems from 0 to 100: authorization, consumer protection, KYC, agent network, transaction limits, and infrastructure and investment environment. The authors used this index to distinguish among regional regulatory patterns and to build our own classification of regulatory frameworks between over- and under-regulation,

constructing key case studies, and ultimately, identifying best practice examples for digital finance regulation (e.g., as found in Ghana).

2.1.4. Regulatory Datasets

Given the non-centralized nature of African government websites, regulatory information was identified by visiting each individual country's central bank website(s). Oftentimes, there would not be sufficient information to paint a full picture, which prompted the use of more specific regulating entities' websites. When a specific government was too fragmented into multiple regulatory agencies to efficiently locate needed data, the researchers found it was more task-specific and efficient to use third party websites applicable to mobile and data laws, such as Thomson Reuters guides. This was essential in building a fuller picture of regulatory practices across different countries and identifying how they impacted the development of local mobile money and digital payment services. On some government websites, however, it was extremely difficult to extract any applicable information on the topic (mainly principle-based regulatory systems); examples of this include regulatory information on Liberia, Sierra Leone, and Chad.

2.2. Informational Interviews

The authors additionally conducted a series of informational interviews with geographic and sector experts within the African digital finance space to gather qualitative insights following a review of equity funding data within the African digital financial services sector. These experts included managing and regional directors of incumbent companies in the sector, reporters, entrepreneurs within the fintech space, regulators and government officials, investors, and academics specializing in fintech. Most interviewees were geographically based in the major fintech hubs of Africa (Nigeria, Ghana, Kenya, South Africa, etc.), with a few located in North America and/or Europe. These interviews were not recorded and were solely used to inform research directions for further database selection and subsequent analyses.

3. Results

The analysis conducted in this study first focused on an evaluation of the present state of digital finance in Africa, incorporating an ecosystem map to identify the geographical and industry distribution of current and emerging fintech players across the continent. We next analyzed the fundamental and ongoing trends determining the environment in which digital finance in Africa is present and will be taking place, identifying both critical near-term and longer-term factors that will shape this landscape in the years to come. These analyses were then used to identify existing gaps in support necessary for stakeholders within an African context to engage with developing digital financial tools in an inclusive, resilient, and sustainable local manner. The results are clustered in four main groups of findings presented below.

3.1. Funding Distribution

Distribution of the total USD 1.1B in VC funding across Africa is highly stratified, with 70% concentrated on payment solutions alone. While serving an immediate need across the continent, this concentration of financing neglects to build up the financing (USD 68M in funding, or approx. 6% of the overall landscape) and investment services (USD 35M in funding, or 3% of the overall landscape) necessary to strengthen the African digital financial ecosystem in the years to come (Figure 1).

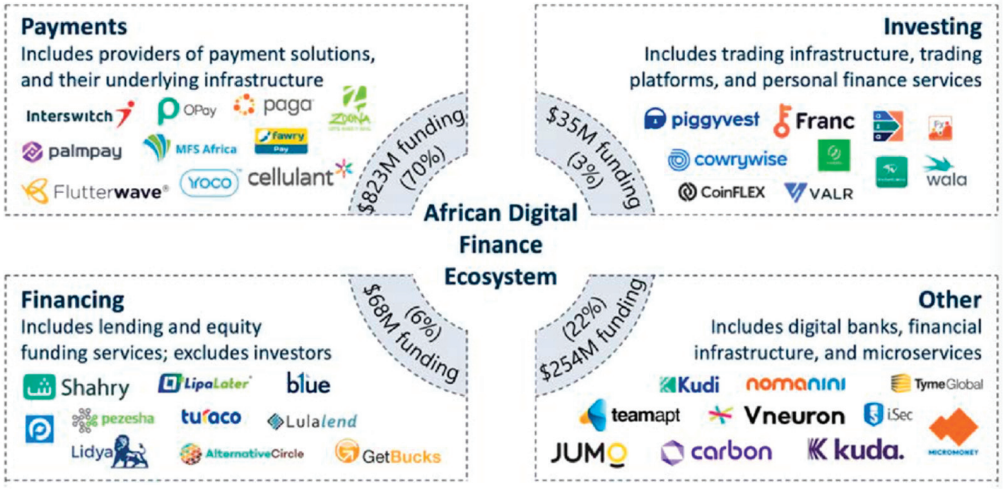

Figure 1. Ecosystem map of the geographic and industry distribution of current and emerging fintech players across Africa (current March 2021).

The authors identified a total of 514 fintech companies offering digital financial services (DFS) operating across the African continent. Most of these companies have received comparatively little funding; 98 have received over USD 100K, and only 50 companies have received funding over USD 1M. This has resulted in a total of USD 1.2B in equity funding within the African digital financial services (DFS) sector since 2000. By comparison, fintech investments in the US reached USD 75B in 2020 alone [3]. This funding is expected to increase as rising interest in online services, including e-commerce, continues to expand, especially following the COVID-19 pandemic.

Of the total investments made across the continent, 70% (USD 823M) is concentrated in payments. These include providers of payment solutions and underlying infrastructure. Notable businesses within this space include Interswitch, which reached 'unicorn' status after a recent funding round led by Visa in November 2019 [4]. Other sub-sectors within the fintech space have received only limited funding. Financial solutions account for 6% of total funding, while fintech enabled investment services account for only 3%. Other financial services, including digital banks and (non-payment) infrastructure providers, account for the remaining 22% (USD 254M).

Funding remains heavily geographically concentrated in a small number of countries across the continent. Of existing fintech funding in Africa, 91% has gone to the "Big Four": Nigeria, South Africa, Kenya, and Egypt. By comparison, fintech companies headquartered in all other 50 African countries have received only USD 109M in total funding since 2000. With this concentration of funding has also come a concentration of talent development. Those interested in the fintech space have relocated to these specific hubs, with the resulting tech workforce developing strong experience from working in an increasing number of tech companies.

Finally, telecommunications companies (Telecoms) function as key gatekeepers given the varied geographic landscape and concentration of robust infrastructure primarily in select urban areas, resulting in large swathes of rural-based populations reliant on mobile phone services. Other traditional gatekeepers include financial services and technology incumbents, governments, regulators, and venture capital investors.

Opportunities within the fintech space have expanded as hard and soft infrastructure across the continent has continued to gradually improve due to a mixture of domestic and foreign investment [5–7]. Recent reports have noted that while the energy, water, and sanitation infrastructure sectors are still in greatest need of financing, telecommunications infrastructure is performing significantly better than any other sector [8]. Smartphones (via telecoms) remain the primary method of financial services access for many. Early mobile money services (such as M-Pesa) historically dominated their national fintech landscape,

though, in recent years, new channels have continued to open for e-commerce, ride-hailing, and digital entertainment (e.g., offering opportunities around payment services, user lending, merchant lending, etc.)

3.2. Unaddressed Pain Points: Merchant Payment Suppliers

The authors identified that merchant payment suppliers experience the greatest pain points around the informal businesses that constitute the core of the African economy. That market is split between small urban businesses and townships' informal retailers, street vendors, and (for example) hair salons. Despite the high concentration of funding in the payment solutions space, our analysis further identified multiple existing, unsatisfactorily addressed pain points within customer journeys across the continent. Such gaps suggest an untapped potential for the emergence of new ventures meeting these needs in the coming years—dependent, of course, on other foundational conditions being met across the overall landscape.

Businesses providing merchant payment solutions occupy an essential stage in the financial inclusion process. The prevailing cultural attachment to cash is often reinforced by technological limitations but is not necessarily supported by all users (e.g., due to security reasons). In that sense, a further limitation that must be addressed is a lack of payment processing methods among merchants outside of highly developed urban areas. Unsurprisingly, cash prevalence increases as density and city size decline. The difficulty of reaching small businesses at scale in those areas has made it prohibitively costly and unprofitable for banks to expand their card servicing network outside of most big cities in Africa. As a result, customers with bank accounts from specific regions are unable to pay with their cards.

In short, merchant payments are a key link in developing the digital finance ecosystem across Africa and an opportunity for supporting local and inclusive innovation. When ineffectively run or poorly disseminated, merchant payment systems break the diffusion of digital payments and instead force users to return to ATMs, wait in long queues, and expose individuals to related security issues. Though its effects still remain to be seen, there is a distinct possibility of the recent COVID-19 pandemic catalyzing the dissemination of contactless merchant payment systems, as has been similarly observed across many other parts of the world.

Countries within Africa where 'first-stage' digital payments and banking solutions are not yet widely disseminated are not seen as suitable candidates for merchant payment suppliers, as initial digital finance infrastructure is necessary for demand to exist. There is an existing unfulfilled need among merchants for non-cash payment, but the informational interviews, literature review, and database analyses conducted for this study suggest that it has not yet shifted to active demand in places where digital and card payments remain insignificant. We find that similar reasons to restricted credit solutions dissemination are also behind this: cash prevalence due to cultural attachment being further reinforced by poor energy and internet connections, with reticent regulators slowing down the adoption of digital payments, all culminate in limited merchant demand for business solutions bridging the payment-acceptance link. Here, we can picture a critical user threshold above which sufficient customers adopt digital payments technologies for it to motivate the merchant-side shift to payment acceptance solutions. Until this occurs, merchant payment solutions will remain limited. In countries where digital payments have already developed, however, payment acceptance has become more naturally integrated.

3.3. Uncoordinated Regulatory Landscape: Under- and Over-Regulation

A significant historical barrier limiting support for local development of products and services in Africa's digital finance space has been the tendency of individual countries to either over- or under-regulate digital finance products and/or services. Given both (a) the novelty of many of these emerging products and services, as well as (b) the difficulties governments in both the developed and developing world face in classifying them within

existing financial services or technology sectors, we find that there needs to be a greater ongoing dialogue between stakeholders. Specifically, innovators and regulators must reach a balance allowing innovation within the digital finance sector alongside the protection of these same users, as well as greater coordination across countries and regions within the African continent.

The authors have identified three broad types of regulatory environments. Briefly summarized, the 'South African' model is one where the regulatory environment seeks to encourage merchant payment challengers through sandboxes but is generally highly bureaucratic and slow to react. A 'Tanzanian' or 'Nigerian' model, on the other hand, historically results in unpredictable and stifling policies by authorities who seek to exercise an extremely high degree of control against challenger fintechs and in favor of incumbent merchant payment suppliers. Finally, the 'Kenyan' model is one where authorities have so far let dominant telecom providers act freely to exploit their existing large user data resources, creating information asymmetries versus new challengers entering the market. Further country-level case studies offer greater analytical depth regarding the challenges faced (e.g., of under-regulation in Kenya, overregulation in Nigeria, and a current best practices regulatory model in Ghana), though they will not be presented in this proceeding due to space constraints.

3.4. Critical Further Roadblocks to Growth

Access to talent, funding, and hard infrastructure were identified as the three primary roadblocks limiting growth in the African digital finance landscape based on the literature and databases reviewed. The authors further found that talent has become highly concentrated, primarily in South Africa (greatest pool), with smaller, yet viable, emerging talent pools in Kenya, Nigeria, and Egypt. Funding access, too, currently remains concentrated in viable ecosystems though it remains below the global average, as previously mentioned. New ventures in other African markets also continue to face difficulties in accessing equity financing due to a higher risk profile. Finally, access to reliable hard infrastructure remains a significant hurdle. Stable internet connections, electricity, and (for more remote or disadvantaged users) access to basic mobile phones remain barriers that must be overcome for the digital finance sector to flourish across Africa. Yet, these same hurdles presently remain restrictive due to the financial cost and regulatory complexity of internet infrastructure coupled with cross-border interoperability.

4. Discussion

Based on these findings, we argue that providing strong, foundational support for local digital financial innovations will increase inclusivity and micro-, small- and medium-sized business resilience across Africa. Yet, the potential to do so is currently hindered by five specific support gaps that can be addressed through concrete stakeholder actions. Those identified include: (1) redistributing the concentration of funding beyond payment systems to also include digital financing and investment services; (2) addressing significant customer pain points in existing digital finance products and services, particularly for merchant payment suppliers; (3) greater regulatory coordination appropriately balancing regulatory sandboxes with consumer protections, especially for mobile money lending services; (4) addressing unequal concentrations of talent; and (5) strengthening access to reliable hard infrastructure, especially within landlocked countries. Addressing these gaps is likely to enable further local-level growth and innovation within the digital finance sector, resulting in greater financial inclusivity (especially for the unbanked) and increasing local-level sustainable development resilience.

The findings presented in this study paint an image of a promising yet presently still insufficiently stewarded future for digital finance in Africa. To appropriately leverage the strengths of digital finance as a catalyst for a better social and economic environment across the African continent—while remaining aware of its limitations as a tool—requires focused and coordinated efforts by all stakeholders involved in the specific challenges identified in

this study. Yet, if executed with responsible stewardship, the strengths and opportunities of digital financial tools have the possibility of creating a more fair, just, and bountiful future for all.

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Perspectives for a Green Deal Framework in Latin America †

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Abstract: The COVID-19 pandemic spurred global discussions around a sustainable recovery that could build back better economies by mitigating emissions while bringing to light the Green Deal frameworks led by the U.S. and the E.U. from 2019. This article presents the main points embedded in the existing Green Deals and offers proposals to serve as templates for Latin America and the Caribbean: the Big Push for Sustainability and the Social-Ecological Transformation. By contrasting the American and European Green Deals with more recent proposals, this article explores the main political, economic and social constraints in LAC to recommend a way forward.

Keywords: green new deal; Latin America; Caribbean; climate change; sustainable development; big push for sustainability

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1. Introduction

The term "New Deal" was first used by Franklin D. Roosevelt to describe a framework for labor, economic and infrastructure spending reforms that saved the United States from the Great Depression of 1929. More recently, the term "Green New Deal" was used by Thomas Friedman to refer to the end of fossil fuel subsidies, carbon taxation and renewable energy incentives. Today, this term serves as a symbol of resistance to the climate crisis, calling for a framework of sustainable policies to reduce emissions and achieve social justice in a low carbon economy.

As a response to the COVID-19 pandemic, Green Deals are arising with the narrative of alignment to the global strategy of a sustainable recovery, to promote economic growth through green jobs and resilient infrastructure. With the U.S. and European frameworks leading the way, other countries and regions of the world are starting discussions on a Green Deal roadmap to guide socio-economic development. These initiatives are part of a global joint effort to reduce greenhouse gas emissions and adapt to current and future climate events.

Since the second industrial revolution, the Earth's temperature has increased 1 °C, of which two-thirds occurred since 1975 [1]. According to the Intergovernmental Panel on Climate Change (IPCC), *global warming is likely to reach 1.5 °C between 2030 and 2052 if it continues to increase at the current rate* [2]. With the ambition to keep temperature levels under 1.5 °C, the Paris Agreement was adopted by 196 countries to commit to climate neutrality by 2050. International cooperation is a crucial piece of the puzzle to solve the climate crisis. In one way, countries may support this endeavor by setting up bold environmental policies domestically, and in another, using diplomatic and financial influence to encourage others to follow by example.

The Green Deal is a realization of the Paris Agreement. It is bringing the climate narrative to parliaments and underlining targets that will serve as an incentive for new legislation. This approach has been gaining significant traction in the Global North, whereas the Global South still struggles to tackle other structural problems. Latin America and the Caribbean (LAC) host some of the most vulnerable countries to climate change in

the world, while the region is also rife with social inequality. In order to implement the Paris Agreement, LAC will need a differentiated approach to social, economic and political challenges that may simultaneously address climate change, as well. Bringing the Green Deal narrative to LAC's parliaments is imperative to catalyze sustainable development policies.

2. The American Green New Deal

The Green New Deal (GND) was introduced by Congresswoman Alexandria Ocasio-Cortez (AOC) in the form of a simple resolution originating in the House of Representatives (H. RES. 109) [3] in July 2019. It resulted from the combination of youth's persistence, as members of the Sunrise Movement physically demonstrated their support for the movement at House speaker Nancy Pelosi's office in 2018, and AOC's fierce commitment to climate justice. Joining efforts with Senator Edward Markey, AOC called for a new method to respond to the climate crisis.

This recent approach proposes extensive government spending to protect minority communities disproportionately vulnerable to climate change while decarbonizing the energy sector and delivering on sustainable infrastructure. It also prioritizes labor policies, green jobs and a just transition for those working in the oil and gas sector. In April 2021, prior to Biden's Climate Summit, AOC and Markey reintroduced the GND simple resolution in the House of Representatives (H. RES. 332) [4] and in the Senate (S. RES. 166), though the content remained nearly identical to the previous versions.

Overall, this framework aims to structurally alter the U.S. economy by 2050 through a self-sustaining plan that pledges to refinance itself in fifteen years. It contains a strong appeal to equity and justice while demanding polluting industries to pay the price. For the purpose of this research, the main points of this framework are divided into brief sections to summarize the Green New Deal resolution and help readers understand the main differences between this proposal and others arising worldwide.

- **Energy:** Renewable electricity generation and providing affordable access, meeting power demand with 100 percent renewables, investing in smart power grids, new clean technologies, R&D and upgrading buildings for energy efficiency.
- **Infrastructure:** Decarbonizing the transportation sector with zero-emission vehicles, clean and affordable public transit and high-speed rail. Reducing pollution from manufacturing industries, removing hazardous waste in abandoned sites and ensuring all infrastructure bills in congress address climate change.
- **Land use and Ecosystems:** Collaborating with farmers and ranchers to reduce emissions in the agricultural sector by supporting family farming and investing in sustainable land use. Restoring natural ecosystems, land preservation, afforestation, enhancing biodiversity and protecting waters, public lands and oceans.
- **Social rights:** Providing access to clean water, sustainable and healthy food systems, quality health care, safe housing, economic security, clean air and education, providing resources and training to all people with a special focus on vulnerable communities envisioning equal participation for the Green New Deal mobilization.
- **Labor:** Creating millions of jobs and ensuring economic security to achieve net-zero emissions through a fair transition for all communities and workers with high-quality union jobs offering training and advancement opportunities. Jobs offered will include family-sustaining wages, medical leave, paid vacations and retirement security for all, in addition to protecting the rights of all workers to organize and unionize free of coercion.
- **Justice and Equity:** Providing transparent and inclusive consultation for the GND, partnering with vulnerable communities, labor unions, worker cooperatives, civil society groups, academia and businesses. Repairing historic oppression of minorities including indigenous peoples, communities of color, women and youth. Obtaining indigenous peoples' consent for decisions that affect their territories, honoring treaties and enforcing the sovereignty and land rights.

- **Finance:** Leveraging funding for climate resilience against extreme weather events and investing in community-defined projects and strategies. Providing ownership stakes and returns on investment, adequate capital (including through community grants, public banks and other public financing), technical expertise and other forms of assistance.
- **Commerce:** Ensuring a commercial environment where every businessperson is free from unfair competition and domination by domestic or international monopolies and enforcing trade rules, procurement standards and border adjustments with labor and environmental protections.

Although these commitments indicate a strong narrative of keeping the rise of global temperature levels below 1.5 degrees Celsius, it lacks clear deadlines and requires more public investment needs and baselines for defining more accurate targets. Nonetheless, this framework is a non-binding blueprint, as simple resolutions do not have the force of law nor require the approval of the other house and signature of the president. This also means the stakes are lower in comparison to other forms of congressional action.

Despite its shortcomings, the GND has been a powerful instrument for U.S. climate policy. Multiple elements of the framework have been incorporated into President Biden's climate plans and served as a backbone for pushing additional bills. Financial commitments that were not included in the text are being proposed separately, including a bill to authorize $1 trillion for cities, tribes and territories to fund local GNDs and another allowing $172 billion on public housing over 10 years [5]. Over a dozen new pieces of legislation have close ties to the framework text and others are likely to emerge, inspiring similar congressional interventions and congruent environmental plans globally.

3. The European Green Deal

Unlike the American GND, the European strategy is a legally binding set of policy initiatives with the underlying goal of reaching zero net emissions by 2050. It is designed to spark legislative action in the European Commission, serving as the foundation of the European Climate Law (ECL) [6]—a legal proposal to consolidate the Green Deal proposed targets, requiring all EU Institutions and Member States to comply. In addition to meeting carbon neutrality, the ECL will create a system for monitoring progress, providing predictability for investors and ensuring the climate transition is irreversible.

While the European Green Deal (EGD) was enacted in December 2019, the ECL only reached a provisional agreement status in April 2021, and is currently being prepared for formal adoption. Meanwhile, on 14 July 2021, the European Commission published the "Fit for 55" package, a set of legislative proposals centered on the EGD targets put forth to reduce greenhouse gas emissions by 55 percent by 2030 compared to 1990 levels. This wave of climate commitments seeks to enact structural changes towards a more competitive economy that prioritizes justice and inclusion to safeguard the environment.

By decarbonizing the energy, industry and transportation sectors through a circular economy approach and adoption of new technologies, the EGD lays out an investment plan worth €1 trillion, with annual investments of €260 billion—approximately 1.5 percent of the block's GDP in 2018. Thereby, it foresees a greater participation of the private sector and a new mechanism to support sustainable projects and technical assistance to boost new investments. In total, €40 billion are expected to fund a just transition, repurposing jobs and enabling the phase out of fossil fuels.

In this framework, where circular economy holds an esteemed role to spur sustainability in domestic supply chains and global economic cycles, there are similar trends as indicated in the U.S. GND and new relevant topics such as food security and technology:

- **Energy:** Promotion of energy efficiency and public buildings renovation, elimination of coal, decarbonization of the gas sector and increased renewable production. Implementation of smart and hydrogen networks, carbon capture and storage (CCS) and energy storage. Interconnection and digitization of the European energy market at the lowest possible cost to combat energy poverty.

- **Transportation:** Enhancement of multimodal transport efficiency to reduce emissions, foster intelligent traffic management systems through digitization and prioritization of rail and maritime transport for road freight transport.
- **Land Use and Ecosystems:** Compensation for farmers achieving better environmental performance to encourage use of low carbon farming techniques. Significantly reduce the use of chemical fertilizers, antibiotics and pesticides to incentivize sustainable food consumption and promote healthy foods at affordable prices for all. The biodiversity strategy comprises forest policies, protection of marine zones and elimination of illegal fishing. Reforestation, preservation and restoration of forests in Europe while promoting the bioeconomy.
- **Food security:** Reduce the environmental impact of food processing and trade sectors through the "farm to fork" strategy, to target changes in transport, storage, packaging and food waste sectors. Food imports are subject to environmental standards on EU markets.
- **Circular Economy:** Value its technological potential to generate jobs, especially for energy-intensive industrial sectors such as steel, chemical and cement industries as the center of the transition to a circular economy, as well as resource-intensive sectors such as textiles, civil construction, electronics and plastics. By 2030, all packaging used on the EU market will be reusable or recyclable following the establishment of a regulatory framework for bio-based and biodegradable plastics, and will apply measures on single-use plastics.
- **Technology:** Use artificial intelligence systems, 5G technology, proximity and cloud computing and the Internet of Things to maximize the impact of policies to address climate change, to offer opportunities to monitor air and water pollution from a distance, optimize the use of energy and natural resources. Partnerships will be undertaken with industry for innovation in the transport sector, including batteries, clean hydrogen and zero emission steel production.
- **Justice and Equity:** Protect vulnerable citizens and provide access to requalification programs and employment in new economic sectors through cooperation with Member States. Environmental education and training programs will also be exchanged across EU networks for better practices.
- **Finance:** Encourage change in behavior of businesses and consumers via carbon pricing, to attract more sustainable investments, revise the tax system, eliminate fossil fuel subsidies, create an energy taxation directive, review tax breaks for aviation fuels and shipping and shift the tax burden from labor to pollution.

One of the overarching values of the EGD is to foster international cooperation and establish the EU as a global leader in these core components of the strategy. While the American GND alludes to cooperation while maintaining its essence on the domestic context to become an international leader on climate action, the EGD underscores the ecological transition as a central goal of foreign and security policy. Moreover, beneath the EU's rhetoric lies the intent to influence environmental standards in trade and exports, forming green alliances and using economic weight in climate diplomacy [7] to be recognized as supreme leader of this agenda globally.

The political mobilization towards climate resilience demonstrated the EU's aspiration to set the rules of the game by defining carbon prices, a border adjustment mechanism for imported carbon (The CBAM is a trade mechanism in compliance with the World Trade Organization (WTO) to reduce the risk of carbon leakage. EU importers may buy carbon certificates corresponding to the carbon price that would have been paid, had the goods been produced under the EU's carbon pricing rules. If a non-EU producer has paid a price for the carbon used in the production of the imported goods in a third country, the corresponding cost can be fully deducted for the EU importer) and an enhanced Emissions Trading System (ETS). Likewise, EU aid and other investments are expected to shift from fossil fuel projects and require environmental, social and governance criteria. Such achievements are seen with great optimism by environmentalists everywhere, but

this strategy could backfire diplomatically since it may jeopardize economic relations with other parties.

4. The Latin American Context

Global carbon emissions in 2018 reached 47,515.3 $MtCO_2$, from which 41.5% came from China (26.1%), the United States (12.67%) and the European Union (7.52%), followed by India (7.08%), Russia (5.36%), Japan (2.5%) and Brazil (2.19%) [8]. In total, Latin America and the Caribbean (LAC), led primarily by Brazil and Mexico stand for less than 10% of global CO2 emissions [9]. However, emissions from LAC have different characteristics than the top six emitters—instead of stemming from the energy sector, CO2 is a result of land use and agricultural practices since the region's electricity matrix is cleaner than the global average. In order to identify the foundations of a regional green deal, it is important to highlight key aspects of historical events that explain the current environmental and socio-economic context.

The LAC region is the most unequal society in the world in terms of income and wealth inequality, classified as middle income on the global scale [10]. According to the United Nations Economic Commission for Latin America and the Caribbean (ECLAC) (2019), disparate income levels led the region to a double inequity trend, where lower classes have a meaner contribution to emissions while being more vulnerable to climate events with people living in outskirt locations and having less resources to adapt. This condition was underscored by recent economic gains in the region that changed consumerism patterns and increased dependence on private non-essential goods—the antithesis of sustainable economic development.

Colonialism shaped the region's governance and social division of labor. Most countries became independent in the 19th century, perpetuating a system that consisted in the concentration of property, income and social inequality. *Economic growth has failed to overcome the region's historical pattern of dependence on the exploitation of natural resources, which negatively impacted ecosystems and biodiversity* [10] (p.31). As stated in "Enough! The Urgent Need for Social-Ecological Transformation in Latin America", progressive governments arose in the first part of the 21st century with redistributive policies and pledges of diversifying economies that depended on commodities and natural resources to survive.

This reliance on environmental exploitation in exchange for GDP growth leads to economic and climate vulnerabilities that harm subaltern populations the most. The market fluctuations on raw materials that led to the early 2000s commodity boom (According to the International Monetary Fund (IMF), *soaring commodity prices were a hallmark of the global economic boom from 2003 to mid-2008. After the global financial crisis, prices crashed and the end of the commodity boom seemed imminent. Instead, commodity prices rebounded in the early stages of the recovery, and by the end of 2010, prices of many commodities were close to or above precrisis peaks*) also severely hampered Latin American economies post-2014 due to plummeting prices. Leftist governments who benefitted from exports and revenue increases to fund assistentialist (government programs that aim to reduce structural social inequality by offering basic public goods for impoverished populations. It often has a negative conotation because it may lead to a level of dependence between citizens and the government) policies found themselves with empty pockets and a population demanding public services. Economic dissatisfaction downturn was aggravated by corruption and loss of faith in the government.

Latin American democracies are young in comparison to many global countries, as they faced dictatorial regimes until the 1980s and are still in the process of strengthening institutions. Political fragility, coupled with rising unemployment rates and poverty levels, fueled the recent rise in right-wing governments. Evidence shows climate skepticism is intertwined with rightist politics. In European countries where right wing populism thrived, as in Poland and Hungary, there has been an effort to scale back climate policies, similar to former U.S. President Donald Trump's effort to withdraw from the Paris Agreement [11]. Brazilian President Jair Bolsonaro, an open climate denier, has backed

policies to drive deforestation, supported fossil fuels and rejected international funding for nature-based solutions.

The U.S. and the European Green Deal frameworks both have strong democratic values and a social justice approach that requires substantial government funding and strong institutions. As for LAC, these pillars are major political challenges in countries with unstable democracies, where the COVID-19 pandemic prompted higher debt levels and jeopardized sustainable rebuilding with equality [12]. In light of reigning colonial structures and public debts, a green narrative must seek to solve structural socioeconomic struggles while delivering on climate resilient solutions that are financially reasonable.

5. Shaping the LAC Green Deal

Finding a pathway to a Green Deal in LAC will involve redefining economic growth, reconducting public investments towards egalitarian policies and eradicating poverty. This transformation will be accompanied by political and economic democratic values that produce equitable conditions of life, leaving none behind while building local capacity. Environmental progress cannot be achieved without those living in urban peripheries and rural areas where poverty rates are highest. Developing climate awareness and skills in the poorest zones of LAC is a stepping stone to achieve a new sustainable economy.

ECLAC created an economic model to eradicate poverty in the region based on redistributive policies in which the government transfers 1.5% of the GDP in the first year (2021) to the poorest and increases the total amount in 0.5% every year until it reaches 3.0% of the GDP in 2024—enough to reduce poverty by 2030 [13]. This strategy is built on the premise that technology transferred from developed countries may compromise local development and employment generation, while potentially increasing political barriers and inequality. Boosting local capacity as a national strategy is a critical incentive for sustainable job creation that also promotes community empowerment and a sense of collectiveness.

Understanding the economic growth rate necessary to reach social equality will demand a coordinated framework of public policies that has been named by ECLAC as the "Big Push for Sustainability". Egalitarian public investments must accelerate local capacity to solve environmental issues while enhancing productivity across all sectors. The Big Push is a joint effort between the public and private sectors to design national strategies and priorities that include environmental resource management, the development of technological and productive skills, economic efficiency and commitment to international treaties such as the Paris Agreement [14].

Furthermore, the COVID-19 pandemic contributed to the largest recession in LAC in at least a century. The World Bank estimated a 7.2% decline in regional economic activities in 2020, the deepest fall in the world [15], which could aggravate old problems and intensify the ongoing environmental crisis. For this reason, the Big Push calls for a self-sustaining growth model that realigns socioeconomic policies with climate demands. The Friedrich Ebert Foundation (FES) also proposed a similar approach that envisions a "Social-ecological Transformation" focused on community self-sufficiency, justice and sustainable levels of well-being coalescing with the public sector's ability to use democratic frameworks to reduce socioeconomic discrepancies [10].

This model reinforces previously stated criteria for the U.S. and E.U. Green Deals, comprised of inclusive institutions, plural participation in decision-making, respecting diversity and improved access of public goods to offer equal opportunities to all social groups. The Social-ecological Transformation aims to address structural inequality and environmental degradation by enforcing democracy and the rule of law to move towards a low carbon economy with equitable distribution of wealth.

The convergence point of these frameworks and the existing Green Deals is the consolidation of a Welfare State (Merriam-Webster defines Welfare State as "a social system based on the assumption by a political state of primary responsibility for the individual and social welfare of its citizens". It is a system where the government provides social

services (healthcare, education, etc.) to promote economic and social well-being of the citizens through the equitable distribution of wealth) centered in an emissions free economic model. While European countries already have redistributive policies, progressive tax systems and generous social programs in place that favor the inclusion of environmental aspects in the existing legislation, the U.S. formation as a federation state challenges this model [16]. The American constitution was designed to protect private property, and American voters do not favor polices to redistribute their income to the nation's poor, who are vastly represented by racial and ethnical minorities. In "Why Doesn't The US Have A European-Style Welfare State?", the authors argue that *race is the single most important predictor of support for welfare, thus America's troubled race relations are clearly a major reason for the absence of an American welfare state* [16] (p. 4).

The LAC region resembles the U.S. in the sense that federalism constrains the prosperity of a welfare state. Since the redistribution of resources is often facilitated by government centralization, as demonstrated by the EU model, federalism hampers the state's ability to equally allocate public goods and tends to prioritize territorial social policies. These issues have led to political unrest in LAC and the inability to combat social inequality, which may indicate that *federal institutions limit the welfare state through lower centralized taxation and politicized interregional transfers that sustain or even increase existing interregional inequalities* [17] (p. 167).

As the Green New Deal seeks to redeem the essence of Roosevelt's original New Deal to reshape political and economic policies based on the Welfare State, it may fail to address structural issues of justice and redistribution due to federalist government structures, both in the U.S. and LAC. For the latter, the lack of financial resources and rising public debts deepens the unlikelihood of achieving a Green Deal based on Welfare State principles in either the U.S. or LAC. In this sense, by inviting the private sector into this process (similar to the Socio-Ecological Transformations proposal to strengthen governments' planning capacity with the help of economic actors), the Big Push narrative is more appropriate for both the U.S. and LAC.

6. Conclusions

Just because the Green Deal frameworks analyzed in this article have a forceful Welfare State premise does not mean this narrative, as it is, would not work in LAC. On the contrary, the objective of this research is to outline the main points defended in the U.S. and European proposals to assess their applicability to the LAC political, economic and environmental context. As mentioned before, the starting point of the existing Green Deals is the energy transition, which still needs to be enforced in LAC, but is not the main driver of greenhouse gas emissions. Thus, creating a Green Deal framework would require prioritizing low carbon land use techniques, building sustainable infrastructure to improve livelihoods, strengthening democratic institutions and promoting social equality by eradicating poverty.

There is innumerous notable research supporting these action areas, including baselines and economic models suggesting a pathway for policymakers. Notwithstanding, these efforts have not been translated into politics. What I argue is the importance of bringing such findings to government through the executive and legislative branches. The most important thing to learn from the U.S. and European Green Deals is that both were introduced as pieces of legislation in their political system. Fortunately, ECLAC's Big Push for Sustainability is being discussed with Brazilian politicians in the national level, and similarly, this should happen to all LAC countries and repercuss in local governments.

The Paris Agreement became a historical milestone for climate action because for the first time, 197 countries signed an international treaty that demanded local ratification—which should have served as a catalyzer of Green Deals in parliaments. It is of utmost importance that these agreements are adapted to the local context and implemented in developing countries with the support of developed nations. In this sense, the principle of common but differentiated responsibilities foreseen in the Paris Agreement must be acknowledged, as it recognizes that developed countries should lead emission reduction

and support developing countries in their targets by providing financial assistance and understanding different capacities to engage in the framework.

With that in mind, the role of international cooperation through trade and financial mechanisms is key not only to implement the Paris Agreement but also to support the development of Green Deal frameworks domestically. An interesting component of the European Green Deal is the will to make use of their international influence to mobilize financial resources towards this cause, involving the United Nations, the G7, G20, World Trade Organization and other governments. Nonetheless, we must be cautious of this climate leadership being established by developed countries not to fall under the imperialistic trap that ignores the real needs of the Global South.

Having binding agreements internationally and domestically is important, but what they achieve with ambition they lose with the lack of penalty for noncompliance. Without going into detail, those sectors most responsible for emitting greenhouse gases should be financially penalized to encourage structural change in businesses. Once again, caution is needed when Green Deal frameworks allude to defunding fossil fuels and other industries in developing countries that heavily depend on these markets to maintain their fragile economies. The role of developed countries should not be to impose new trade and finance rules but use their soft power to drive new business models and governance based on better practices that enable a global green transition within the reach of developing countries.

Since these governments have scarce resources and need to prioritize other agendas such as health and education, they will not be able to solve the climate crisis alone. In addition to formulating national Green Deal frameworks, I defend a wider participation of the private sector, businesses and industries to achieve this goal while offering new channels of participation for civil society and especially consulting with minorities and vulnerable communities. Instead of trying to replicate the Welfare State in LAC and other regions of the world, the international community should be focused on leading by example and providing support for technical assistance and capacity building.

With enhanced skills on the ground, the LAC Green Deal will arise from the bottom-up without needing to copy other frameworks but building on local knowledge to diversify economies, increase productivity without compromising environmental resources, grow new sustainable businesses and progressively reduce inequalities. All of this must be achieved bearing in mind the need for more equal distribution of public goods and prioritization of local climate needs in federated societies. Sustainable development should be the cornerstone of government action to improve climate governance and provide guidance to bolster the coordination of policies related to infrastructure, social welfare and public expenditure.

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Accelerating Science-Driven Blue Growth via a Competitive Intelligence Cloud/HPC Platform for AI-Based STI Policy Making †

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Abstract: SDSN Greece, the Black Sea and the Mediterranean, supported by SDSN Europe, have established the Sustainable Euro-Asian Seas Initiative (SEAs) to accelerate science-driven blue growth and SDG implementation in the Euro-Asian Seas and beyond. IntelComp (H2020 project) seeks to build an innovative Cloud Platform that will offer AI-based services to public administrators and policymakers across Europe for data- and evidence-driven STI policy design and implementation. One of IntelComp's main focus areas is the climate change challenge, targeting the Blue Growth perspective. Within the project's framework, Living Labs will take the role of implementing a co-creation approach and engaging all relevant stakeholders to explore, experiment with and evaluate STI policies at all stages.

Keywords: blue growth; blue economy; sustainable seas; SEAs Initiative; IntelComp; STI policy; living labs

1. Introduction

The IPCC 2018 Report [1] warns that exceeding a 1.5 °C increase in global temperature above pre-industrial levels will lead to unprecedented effects to health, livelihoods, food security, water supply, human security and economic growth. This will be catastrophic for our seas and oceans, which are drivers for the European economy and have great potential for innovation and growth. Two essential components to provide knowledge, legal certainty and security in the blue economy are the following: ensuring marine knowledge to improve access to information about the sea and enforcing maritime spatial planning to ensure efficient, sustainable, job-based and inclusive management of activities at sea. The SDSN Sustainable Euro-Asian Seas (SEAs) Initiative seeks to accelerate science-driven blue growth

and the implementation of the United Nations Sustainable Development Goals (Agenda 2030) in the Euro-Asian Seas and beyond. SDSN SEAs Initiative is led by SDSN Greece, SDSN Med and SDSN Black Sea via SDSN Europe. IntelComp (funded by H2020) is setting out to build an innovative Cloud Platform that will offer Artificial Intelligence-based services to public administrators and policymakers across Europe for data- and evidence-driven policy design and implementation in the field of Science, Technology and Innovation (STI) policy. One of the three pilots of the IntelComp project is the climate change challenge, targeting the Blue Growth perspective. IntelComp proposes a framework for a co-creation ecosystem to make policies "with people", seeking to bridge the gap in information flow and empower a broad group of stakeholders to actively participate in agenda-setting and policymaking, implementation and monitoring. Instrumentally, Living Labs are proposed to implement this co-creation approach, engaging public policymakers, academia, industry, SMEs, local actors, civil society and citizens to explore, experiment with and evaluate STI policies at all stages.

2. Climate Change in the Mediterranean, Caspian and Black seas

The Mediterranean Sea is one of the ocean regions that is warming fastest [2] due to its geographical position between the semi-arid and arid climate of North Africa and the temperate climate of Central Europe, leading to a climate particularly vulnerable to minor modifications of the general circulation [3]. Additionally, the Mediterranean's semi-enclosed nature restricts the hydrological exchange with the open ocean, allowing the Mediterranean to store heat. This semi-enclosed nature makes the endemic marine biota extremely vulnerable to alterations to their environment, as several pieces of research have shown [2,4–6]; this has led to significant decreases in local populations of cold-water species, while easing the arrival and adaptation of alien species through the Suez Canal.

The mean temperature of the Mediterranean basin has increased 1.4 degrees Celsius since the late 19th century, compared with the global average of 1.1 degrees. This value is projected to increase by an additional 1.5 degrees by 2050 [7], leading to an increased risk of drought, water stress and extreme natural events, such as wildfires and floods. Climate change affects the Mediterranean Sea on multiple levels. The already uneven distribution of water resources will pose a greater challenge as freshwater resources will be less available due to significant expected increases in the length of meteorological dry spells [8]. As a result, river flow and lake levels will be reduced and combined with the sea-level rise and the increased groundwater use for agricultural purposes will aid in salt-water intrusion, which is already a major issue in regions located by the sea. Seasonal changes that already take place in the Mediterranean area in a combination of mixed land use, are responsible for drier lands and a higher fire risk, longer fire seasons and severe fire events, which can already be seen in the latest forest fire events that took place in Italy, Greece and Turkey. Another major challenge arising from climate change and the interconnection of land and sea is food production, as extreme events may bring losses to crops, while ocean warming and acidification directly impact fisheries and aquaculture. Finally, due to temperature increases, new challenges in human health are emerging. Increased temperature eases the transmission of vector-, water- and food-borne diseases in the Mediterranean, while droughts, water scarcity, food redundancy and economic instability are expected to increase human insecurity and lead to increased migration rates within the Mediterranean region [9].

Similar consequences are expected in the planet's largest inland seas: the Black and Caspian Seas. As is expected, global warming will affect their circulation, temperature and freshwater balance, thus impacting coastal and marine ecosystems.

The Black Sea is a meromictic basin with anoxic conditions below 200 m. As a result, biological life is supported by the upper thin layer (0–200 m), as the deeper and denser water layers are saturated with hydrogen sulfide. An analysis of the circulation patterns in the Black Sea Basin has shown that through the years, a warming trend has been observed in the middle layer of the Black Sea that may alter the stratification of the Black Sea. This means that sulfide, noxious and corrosive chemicals from the bottom of the Black Sea will

be freed to the upper surface layer, ensuing hazardous consequences on the Black Sea's biota [10]. Furthermore, a reduction in wind stress curl over the basin of the Black Sea is expected, which will lead to a speed decrease of the Rim Current circulation, thus affecting water quality, larvae and pollutant dispersal [11].

In contrast to the Mediterranean and the Black Sea, the Caspian Sea is a closed basin. As an endorheic basin that does not have an outflow, its water levels are determined by balancing precipitation, run-off input from the Volga River and evaporation. Models show that global warming will lead to a freshwater imbalance that, integrated over 50 years, will result in a 5 m drop in sea level. This will lead to a great retrieval of the shoreline, greatly impacting the Caspian Sea ecosystems [11]. Other studies argue that in medium to high emission scenarios, the projected fall of the Caspian's water level ranges from 9 m to 18 m [12]. This means that a great area will emerge from under the sea's surface, leading to severe stress on biodiversity and the economy [13]. Specifically, shallow-water habitats will disappear, removing a major food source for fish, migrating birds and the endangered Caspian Seal, as well as spawning grounds for endemic and/or endangered species. Moreover, this decline in the water level will directly affect the economies of the region, especially the shipping activity inside and outside of the Sea via the Volga-Baltic Waterway and the Volga-Don Canal [13]. A qualitative assessment has shown that environmental shifts have already made their impact on the Caspian ecosystem structures and functioning [14].

3. Systems Innovation Approach

Section 2 provided a detailed description of the situation in the three seas, namely, the Mediterranean, Caspian and Black Seas, and this is an essential starting point for the living labs that will follow. The approach that we use to run the living labs is the Systems Innovation Approach (SIA). Systems innovation is defined as an "interconnected set of innovations, where each influences the other, with innovation both in the parts of the system and in how they interconnect" [15]. The SIA represents a fundamental shift in how knowledge generation is perceived, and, as a result, accepted. It turns the focus away from technological breakthroughs and research and onto the entire innovation process, of which research is just one of the components. This framework lays the groundwork for the IntelComp platform's evolution, which will necessitate active engagement in agenda-setting and policy-making, as well as execution, monitoring and collaboration among key stakeholders.

The foundations of the SIA include creating a conducive environment for stakeholders to express their opinions and achieve a holistic understanding of their demands. The first step in deciphering the interactions and thinking about how to solve them is to agree on what the problems are. In this paper, we employ a series of bi-monthly sessions with two stakeholder groups: one for the Mediterranean case study and one for the Black and Caspian case studies, as presented in Figure 1. Stakeholders from countries coloured in yellow will be invited to both living labs and represent the connecting players among the two stakeholder groups. The target groups of these living labs are representatives from the government at the national−regional−international level, policymakers, academics, researchers, experts, experienced professionals and technology providers, ensuring scientific support, analysis and democratic feedback on the design of commonly accepted metrics and actions for a sustainable future [16].

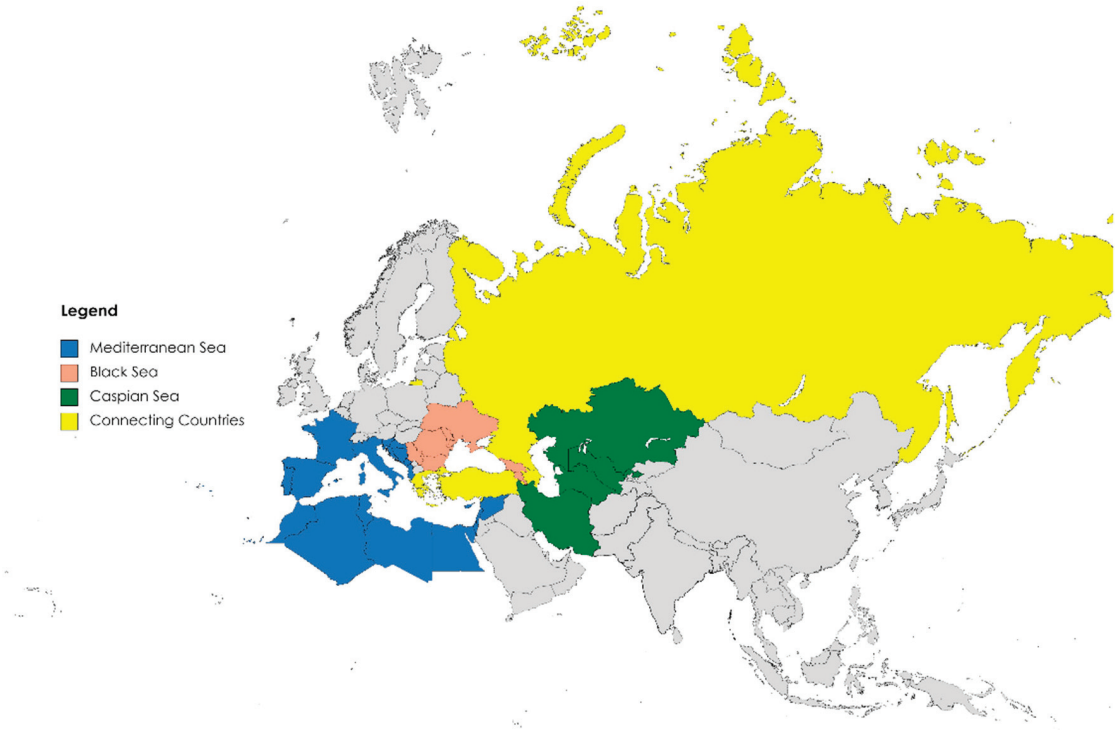

Figure 1. Division of countries into groups (Map created with mapchart.net).

As mentioned above, the first step of the proposed methodology is to present the issue from a scientific perspective based on the literature. The cases of these three Seas are very interesting as the frequency and impact of climate disasters (floods, droughts, extreme weather) will increase within Europe, North Africa and East Asia in the coming decades. To face this challenge and reduce the cost and impact of resulting damage, Europe, North Africa and East Asia need a systemic network offering easily accessible information.

The next step is the stakeholder management process. This process is composed of two steps: stakeholder analysis and stakeholder engagement. Stakeholder analysis aims to identify desired stakeholder groups, as well as their behaviours, their initial preferences, their requirements and the relationships that govern these groups. At this stage, we employ tools to rate stakeholders on two or three essential traits, identify possible synergies or conflictive relationships and create patterns of knowledge and resource flow, which may be interpreted as power flows [17]. Stakeholder engagement refers to both the approach we will utilize to bring all parties together and the level at which they will be fully incorporated into the process. Stakeholders will be invited to form the core stakeholder group that will engage in the Living Labs based on their preliminary interest, relevance and expertise in the field, or they will be considered latent.

Following the aforementioned gathering of stakeholder representatives, we enable their active involvement in organized workshops, aiming to unravel the problem of climate change in these Seas from a variety of viewpoints (environmental, political, technological, social and economic). During this step, we try to break down the problem into its constituent parts. This stage has two objectives: first, to uncover secret causes and problems that cannot be found in the literature and, second, to unblock the process of deep listening (i.e., the process of listening to learn). The latter has far-reaching implications, as to advance to the next phases of the SIA, the involved stakeholders must be able to comprehend the perspectives of the other parties for the greatest benefit.

Next comes the multi-level perspective (MLP), which is an analytical method aimed at defining how innovation is generated and the major characteristic of transition in socio-technical systems. The MLP divides the system into three levels: the macro-level (landscape), the meso-level (regimes) and the micro-level (niches of innovation). Exogenous,

long-term, autonomous tendencies and big crises, such as climate change, urbanization and unanticipated catastrophes are depicted at the macro-level (landscape). The landscape can produce tension, which has a huge impact on the other two layers. Regimes are made up of powerful stakeholders who want to keep things as-is. They decide the aspects around which the system is organized, such as legislation, institutions (political, financial, social), user behaviours and cultural values. Finally, the niches of innovation, such as universities, research institutions, R&D departments and the Military, can be thought of as places where innovative inventions and ideas are born. We are trying to figure out how the system surrounding the problem works to identify opportunities or serious risks [17].

After comprehending the problem and its surrounding stresses in a holistic manner, we proceed with the vision development, which is a foresight method that endeavours to create a feasible and desirable future scenario where the current problem is solved. To understand the power of a vision, we should take a deeper look at its foundation, which is expectations. Visions are formed based on collective expectations and, by their very nature, cannot be fully realized, as expectations are adaptable and open to reinterpretation to some extent until the point at which they are realized [18]. Nevertheless, co-developing a vision is essential for agreement on the measures and changes that need to be done.

Finally, to accomplish the co-developed vision, we create change trajectories, that will strive to untangle how the system changes and where innovation originates from. The stakeholders will have the chance to co-develop the needed trade-offs during this phase. We employ methods to aid in the interpretation of sources of resistance and resilience to system changes, as well as the distance between options that co-evolve simultaneously in distinct trajectories and the optimization of co-decided actions under various scenarios using time frames.

Stakeholder co-development of change trajectories can provide credibility to national and sectoral interpretations, while also revealing significant uncertainties or flows. Pecl et al. (2019) argue that involving and educating the public on scientific topics may help to transform people's minds, attitudes and behaviours [19]. This strategy aims to ensure stakeholder commitment to the co-developed solutions by testing the hypothesis that a sense of "belonging" and "co-developing" will lead to behavioural change. The SIA process is followed by leading conversations during meetings and the tools mentioned can be applied using visual collaboration platforms, such as MIRO, which allows for the efficient and effective intuitive cooperation of stakeholders.

4. Primary Results and Future Results

These Living Labs are supported by the UN SDSN SEAs Initiative, which intends to boost science-driven blue growth in the Euro-Asian Seas and beyond, as well as the realization of the United Nations Sustainable Development Goals (Agenda 2030). The initiative aims at gathering the efforts of SDSN National and Regional Networks on Blue Growth in an interdisciplinary framework. A regular annual report on Technological, Economic and Social Transition Pathways of systemic transformation will be introduced, as it is required for the realization of Agenda 2030 in our seas and oceans, including Science-Technology and Innovation-Policy interface agenda-setting, model design, implementation, monitoring and evaluation. This initiative builds on SDSN Greece, SDSN Black Sea and SDSN Mediterranean, which brought together the 4-Seas Initiative, the Global Roundtable for Sustainable Shipping and Ports, the Plastic Busters Initiative, the newly formed Global Maritime Accelerator and several Blue Growth research projects.

The Initiative is coordinated by:

- Phoebe Koundouri, Professor and Director of the ReSEES Research Laboratory, Athens University of Economics and Business; Director of Sustainable Development Unit and EIT Climate-KIC Hub Greece, Athena RC; Fellow of the World Academy of Art and Science; President-Elect of the European Association of Environmental and Resource Economists; Co-chair of UN SDSN Europe and UN SDSN Greece

- Nikos Theodossiou, Professor at the Aristotle University of Thessaloniki, Chair of UN SDSN Black Sea
- Yannis Ioannidis, Professor at the National and Kapodistrian University of Athens, Former President at ATHENA Research and Innovation Centre, UN SDSN Greece Strategic Advisory Board Member
- Andreas Papandreou, Professor at the National and Kapodistrian University of Athens, Co-chair of UN SDSN Greece

Following the process in Table 1, each stage is accomplished through monthly workshops. Due to COVID-19 restrictions, the meetings are held on Zoom and MIRO software is used for the analysis. Each stage is enriched and supported by a variety of tools based on the needs of each workshop and the specificities of the living lab (i.e., what are their interests, needs, conflict points etc.).

Table 1. Living Labs workshop planning (Med is for the Mediterranean Group and BS+CS is for the Black Sea and Caspian Sea Group).

No. of Workshop	Goal of the Workshop
#1 June 2021—Med & BS+CS	The goal of these workshops and introduction to the climate change challenge and the Blue Growth
#2a July 2021—Med #2b September 2021—BS+CS	Understanding the gap between Knowledge and Action
#3a October 2021—Med #3b November 2021—BS+CS	Understanding the environmental challenges
#4a December 2021—Med #4b January 2022—BS+CS	Understanding the technological challenges
#5a February 2022—Med #5b March 2022—BS+CS	Understanding the societal challenges
#6a April 2022—Med #6b May 2022—BS+CS	Understanding the economic challenges
#7a June 2022—Med #7b July 2022—BS+CS	Understanding the policy challenges
#8a September 2022—Med #8b October 2022—BS+CS	Understanding the role of networks
#9a November 2022– Med #9b December 2022—BS+CS	Understanding various stakeholders' perspectives
#10 January 2023—Med & BS+CS	Bringing together all stakeholder groups and discussing the findings of the challenges
#11a February 2023—Med #11b March 2023—BS+CS	Macro-level, meso-level and micro-level perspectives
#12a April 2023—Med #12b May 2023—BS+CS	Vision development
#13a June 2023—Med #13b July 2023—BS+CS	Trajectories of change—Figuring out the way and brainstorming suggested trajectories opportunities
#14a September 2023—Med #14b October 2023—BS+CS	Co-creation of the Socio-Technical Roadmap
#15 November 2023—Med & BS+CS	Final workshop

During our first workshop, we invited stakeholders from both the Mediterranean and the Black−Caspian Seas groups and we asked the participants to introduce themselves and their work after introducing the climate change challenge and its impacts on the seas, as well as the preliminary goals and objectives of the project. We stressed the need for the cooperation of representatives of the state, civil society, scientists, researchers and investors to jointly formulate action plans in line with European and national strategies that will facilitate the acceleration of science-driven blue growth and the implementation of the United Nations Sustainable Development Goals (Agenda 2030) in the Euro-Asian seas and beyond. In this context, Prof. Phoebe Koundouri (Athens University of Economics and Business) briefly presented the political framework for sustainable development, namely the UN Agenda 2030 and the 17 Sustainable Development Goals, the Paris Agreement,

the European Green Deal and the Recovery Fund, which lay the foundations and the financing tools for the creation of synergies and acceleration of sustainable development in these areas.

Dr Haris Papageorgiou (Research Director ATHENA RC) presented the IntelComp (Horizon 2020) Project, titled "A Competitive Intelligence Cloud/HPC Platform for AI-based STI Policy Making", which will support the SDSN SEAs Initiative through a dedicated case study on Sustainable European and Asian Seas and Oceans. IntelComp is setting out to build an innovative Cloud Platform that will offer Artificial Intelligence-based services to public administrators and policymakers across Europe for data- and evidence-driven policy design and implementation in the field of Science, Technology and Innovation (STI) policy. Large STI datasets are processed in High-Performance Computing (HPC) environments that are part of the European Open Science Cloud (EOSC) initiative. Public administration at all geographical and organizational levels, STI stakeholders and civil society produce a great amount of dynamic, multilingual and heterogeneous data (e.g., national STI strategies, plans and work programmes, calls, projects, reports, scientific publications, patents, dissemination articles, etc.), so understanding and analyzing this data is crucial for evidence-based policymaking. The main objectives of IntelComp are to understand the challenges of Science, Technology and Innovation (STI) policymaking in the development of a co-designed, co-creative manner framework with the relevant stakeholders (including the participants of the Living Lab) and the creation of a data space, data-pool or data repository on STI-related data sources and datasets.

The stakeholders who participated in the first workshop came from the triangle of knowledge: namely, research, education and innovation, as well civil society, private sector and public and regulatory authorities. In particular, the following institutions attended the meeting:

- Institutes and Research Innovation Centres
  - Belgium: Centre for Social Innovation
  - Cyprus: The Cyprus Institute
  - Greece: ATHENA Research and Innovation Centre, Hellenic Centre for Marine Research (HCMR), Solmeyea, Machinor
  - Italy: Eurac Research
  - Kazakhstan: Ban Ki-moon Institute for Sustainable Development at KazNU
  - Netherlands: KWR Water Research
  - Spain: Basque Centre for Climate Change
- Universities and Educational Institutions
  - Greece: Athens University of Economics and Business (AUEB), Aristotle University of Thessaloniki (AUTh), National Technical University of Athens (NTUA),
  - Kazakhstan: Nazarbayev University, Narxoz University
  - India: ICFAI Business School (IBS)-Hyderabad
  - Italy: University of Siena, Università degli Studi di Cagliari
  - Moldova: Academy of Economic Studies of Moldova
  - Norway: UiT the Arctic University of Norway
  - Spain: Universidad Carlos III de Madrid, University of Santiago de Compostela
  - Turkey: Yeditepe University
  - U.K.: University of Plymouth
- Civil Society
  - France: SDSN Europe
  - Greece: SDSN Greece, SDSN Black Sea, ECOGENIA
  - Italy: SDSN Mediterranean
  - Kazakhstan: Solar Power Association of Qazaqstan (SPAQ)
- Public and Regulatory Authorities
  - Greece: General Secretariat of Research and Innovation

- Belgium: European Commission, Conference of Peripheral Maritime Regions (CPMR)
- Kazakhstan: Project Office of the Prime Minister of Kazakhstan
- Romania: General Secretariat of the Government—Department of Sustainable Development

The first phase of SIA started in our second workshop when the participants tried to unravel the challenge of data mining. Firstly, they provided feedback on the frequency and accessibility of the international datasets that are most used in research projects, such as the OECD database, the UN Stats relevant sites, Eurostat, the SDSN Index & Monitoring site, the World Bank and the European Policies site, in which someone can find all the EU policies categorized by topic. Next, participants were divided into two (2) breakout rooms, aiming to answer the following questions: What data platforms or monitoring tools exist in their country; how do they get informed; and what is missing. This discussion enabled us to define the problem and get a common ground for future discussions. In our case, most of the participants seem to understand the gravity and the depth of the data identification challenge and agree with most of the different components and details raised during the workshop.

5. Conclusions

The SIA is the hereby suggested methodology for solving complex problems, where system dynamics and stakeholder behaviour define the capability of the challenge to be solved. Policy formulation, adoption and implementation is a complex problem due to the interrelated nature of the stakeholders and their conformity, which they depend upon to achieve different social, economic and environmental goals. The SIA presents a conceptual approach to better understand and systematically analyse the interactions between the natural and economic environment and human activities and to move towards more coordinated management and use of these seas across sectors and scales.

The SIA with proper scientific support is a powerful tool. In the case of the ongoing research in the Mediterranean and the Black−Caspian Seas, it enhances an understanding of the different perspectives, approaches and systemic interlinkages. Moreover, it reveals and addresses deeper shortcomings of the institutional framework, the authoritarian behaviour of the State, misleading perceptions about the management of the seas and weaknesses in the cooperation between stakeholder groups. The co-development of a common vision is a key driver that builds on common understanding and goals under a common purpose, which is higher than individual interest without undermining it.

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Proceeding Paper

Multi-Actor Working Groups as Fora for WEF Nexus Innovation and Resilience †

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Abstract: This paper presents a stakeholder engagement framework, which is built on the systems innovation approach (SIA). The framework is developed to facilitate a decision-analytic platform, structured on a multi-level integrated WEF (water-energy-food) model in order to better understand the multi-sectoral WEF trade-offs, capitalize on potential synergies, and explore the interdependencies as well as feedback across a hierarchy of three spatial scales: (i) micro level, the demonstration site, (ii) meso level, the Nile River basin, (iii) macro level, the Mediterranean region. Operating in the space of multi-actor working groups (MAWGs), stakeholders are guided to identify and examine the WEF Nexus drivers of change, while considering the local ecosystem services and validating project findings.

Keywords: multi-actor working groups (MAWGs); systems innovation approach; multi-sectoral WEF trade-offs

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1. Introduction

The WEF Nexus is a conceptualization of the inextricable linkage between water, energy, and food. It examines the relationship between the three components; how the demand for one resource can drive demand for another, and similarly how an increase in the cost of one affects the other's efficiency of production [1]. The WEF Nexus approach has proven particularly useful in addressing water, energy, and food insecurities in Sub-Saharan Africa, by providing insight to support regional development [2]. The WEF Nexus approach is further developed in the context of the EU PRIMA-funded project, AWESOME (the AWESOME project (mAnaging Water, Ecosystems and food across sectors and Scales in the sOuth MEditerranean) is funded by the Partnership for Research and Innovation in the Mediterranean Area Programme (PRIMA), grant agreement number 1942), to include the dependency of water, energy, and food on ecosystems (e.g., freshwater, forests, scrublands, grasslands, and wetlands)—the Water, Energy, Food, Ecosystems (WEFE) Nexus. These four aspects are directly linked to human well-being and poverty reduction [3]. The approach focuses on assessing and quantifying interactions in a complex system between multiple goals, and the influence of achieving one goal on the fulfillment of others [4]. The method uses an integrated approach in order to analyze the synergies and trade-offs between sectors, aiming to maximize the efficiency of using resources, while adapting policies and institutional interventions [5].

The WEF Nexus has entered the governance discourse, aiming to present the complexity of systems, such as agriculture, through demonstrating physical and institutional connections. In terms of policy, the WEF Nexus aids work towards achieving security for water, food, and energy simultaneously [6], while it is also used in order to identify

potential trade-offs during policy design, and the development of solutions benefiting multiple SDGs [7]. Therefore, the WEF Nexus concept plays a crucial role in achieving the goals of the Paris Agreement and the SDGs [7].

The application of the WEF Nexus is particularly significant in the Mediterranean region as well as in transboundary river basins, such as the Nile basin, where resources are closely tied to existing socio-economic concerns. The Mediterranean region is a geographical area with diverse socio-political, economic, and environmental conditions, where the policies and interventions affecting water, energy, and food have been managed separately [5]. In addition, the problems affecting these critical resources render the area vulnerable within the context of climate variability and change, population growth, and other developmental pressures, such as pollution issues and water scarcity [8], imbalanced water allocation among sectoral users, high demand for food and energy [5], food loss and waste, as well as changing dietary habits.

At 6650 km in length, the River Nile is the world's longest river. It flows from Central Africa to the Mediterranean Sea, with a river basin of 3,500,000 km^2. The Nile basin is experiencing rapid population and economic growth, which is putting pressure on shared resources. At the same time, international cooperation is further challenged by discussions about the Grand Ethiopian Renaissance Dam management. To tackle the hydro-political conflicts among the riparian countries, the Nexus approach has the potential to address trade-offs among the stakeholders in competition for water, energy, and food resources, whilst promoting a deeper understanding of shared benefits [9].

The current water demand for irrigation along the Nile is estimated at 83 BCM; meaning 80% of the entire water demand. This figure is projected to be more than 140 BCM by 2050 if the current level of water management technology continues (https://nilebasin.org/index.php/new-and-events/313-study-aimed-at-addressing-growing-water-demand-in-the-nile-basin-at-final-stage, last accessed on 31 May 2022). This, in combination with demographic projections developed in the framework of AWESOME (https://awesome-prima.eu/wp-content/uploads/2021/06/AWESOME_D21_AUEB_WP2_F_Demographic_scenarios.pdf, last accessed on 31 May 2022) indicates a population of 1.2 billion people in the Mediterranean by 2100, and explains how the demand for water, food, and energy are set to escalate rapidly. In addition, the total current evaporation from dams of 17.2 BCM is constantly on the increase, further contributing to reducing the amount of water available to meet rising demands. The planned growth in installed energy generation capacity is 21,000 MW, while the storage capacity of the planned dams will reach 200 BCM. At the current rate, water demand will soon outstrip the available resources if suitable measures are not put in place, which takes into account the WEF Nexus in order to balance the use of resources between these four sectors, as well as between the upstream and downstream uses.

Spanning 11 countries (Burundi, Democratic Republic of Congo, Egypt, Eritrea, Ethiopia, Kenya, Rwanda, South Sudan, Sudan, Tanzania, and Uganda), one of the most prevalent problems within the Nile basin is the very different degree of water-use efficiency among countries. Egypt, for example, has relatively well-performing irrigation systems with one of the highest water-use efficiencies internationally for crops, such as cotton and wheat [10]. On the other hand, Sudan's poor irrigation systems are causing poor yields due to water inefficiency, poor canal maintenance, and lack of water. Sudan's irrigated agriculture is stagnating with only 1% of its arable land currently irrigated [11]. The application of the WEF Nexus approach is particularly significant as there is a need to consider the Nile basin as a resource basin where all water values (whether direct or indirect) are analyzed; and natural resources, such as land and energy connected to the basin are considered for the cooperation of all water users and the development of the basin as a whole [12].

Water use for food production is a priority within the Egyptian WEF Nexus, and the agricultural sector is the largest user of water resources based on total water needs. Egypt faces water security problems due to inefficient irrigation techniques and over-exploitation of groundwater. In addition, the Grand Ethiopian Renaissance Dam, being 73% complete

as of May 2020, has placed additional pressure on the availability of water [13]. Moreover, food self-sufficiency in Egypt is limited by scarce water resources, thus, 50–60% of food is imported (despite a 20% increase in overall crop production since 2010). In 2017, winter crops' production reached up to 89.8 million tonnes (Mt) while summer crops reached 48.1 Mt tonnes, due in part to land reclamation and sustainable water usage [14]. Although 33% of international trade volumes dropped due to the COVID-19 pandemic, exports rose up to 8.4 Mt in 2020 (in comparison to a mere 5.4 Mt of agricultural products exported in 2019). Another key area of concern is energy use for water treatment and conveyance in the form of fuel-powered and energy-intensive water lifting plants. These aspects are addressed by projects shedding light on the importance of directing efforts to increase water supply through desalination units and wastewater reuse. While this will entail even more energy use, the current surplus in energy generation and the expansion in the renewables sector would make it a viable trade-off. By promoting desalination to increase the national water supply, reusing treated wastewater to recycle nutrients and reduce energy-intensive fertilizers, promoting renewable energy for irrigation systems, e.g., solar pumping, and considering the energy potential of agricultural waste, the WEF Nexus approaches aim to increase water efficiency in Egypt in the agricultural sector by 60% [13,15].

In light of the importance of the WEF Nexus approach within the region, this paper aims to present a stakeholder engagement methodology developed in the framework of the EU PRIMA-funded project, AWESOME, that identifies and examines the relationships between the core drivers of change within the WEF Nexus concept, taking into consideration their interactions with local key ecosystem services. As a multi-tier method, it is designed to support a bottom-up approach towards the scaling-up of innovative solutions, taking into consideration the macroeconomic WEF Nexus development at national and Mediterranean scales; therefore, making it an effective tool to support activities from regional planning at the Nile basin scale, down to a single farm. AWESOME's significance lies not only in its ability to integrate stakeholders' perspectives in order to develop local capacity but also provides assistance to national and regional policies in the Nile river basin and the Mediterranean to go beyond the implementation of the usual WEF Nexus practices in order to ensure a discernible impact in the implementation of Agenda 2030 (https://sdgs.un.org/2030agenda, last accessed on 31 May 2022) and the revival of economies around the Nile.

2. Materials and Methods

2.1. Case Study Approach

The AWESOME project analyzes the WEFE Nexus (water-energy-food-ecosystems) across three special scales, namely: (i) the macro level, which is represented by the macro-scale processes and policies that influence the dynamics of water, energy, food supply, and demand as well as the ecosystem services in the Mediterranean; (ii) the meso level which corresponds to the river basin scale, where the strategic planning needs to take place based on realistic projection and focuses on three main countries crossed by the Nile (Egypt, Ethiopia, Sudan); (iii) the micro level, which is represented by the demonstration site, where experiments on soilless agriculture (hydroponics and aquaponics) take place. The stakeholder engagement approach aims to leverage stakeholders' perspectives to produce a detailed intra-basin analysis at the case study level (micro and meso levels), with the potential to scale up to the extra-basin regional spatial scale with macro-level modelling (Figure 1).

The above approach allows for a better characterization of different technological solutions to produce water and food, as demonstrated at the micro level, while producing a realistic representation of macro-scale processes and policies influencing critical resources and ecosystem services.

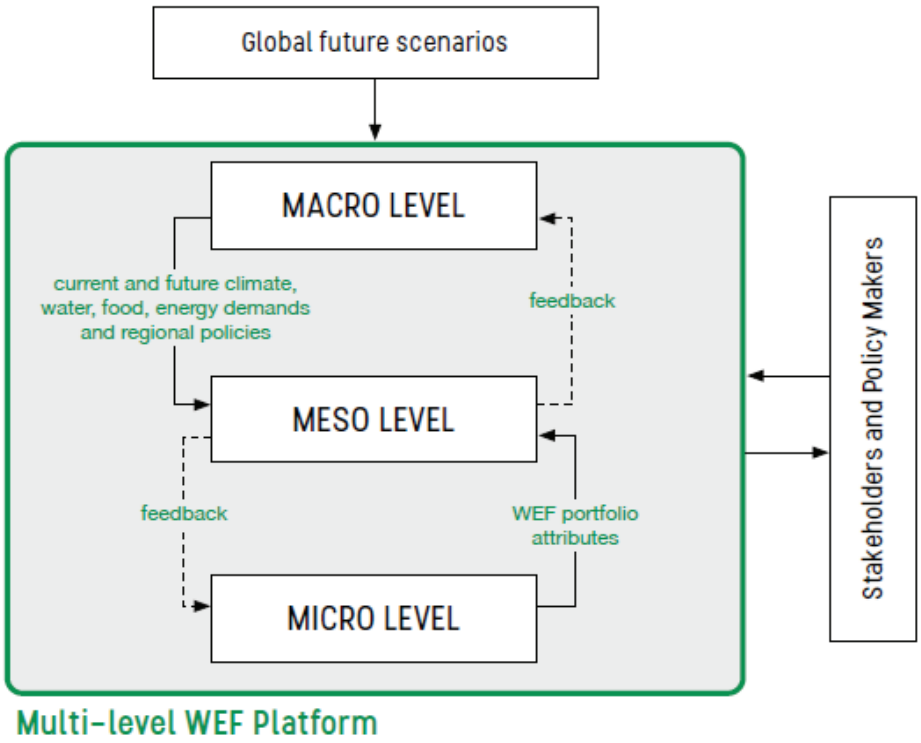

Figure 1. The AWESOME multi-level WEF platform.

2.2. Multi-Actor Working Groups Methodology

The project capitalizes on stakeholder knowledge via structured multi-actor working groups (MAWGs), which engage key local, national, and regional actors from a variety of sectors as "citizen scientists" within the project. These stakeholders support the identification of key WEFE Nexus issues and drivers, as well as provide validation of outputs to ensure results are grounded in the real world and relevant for end-users. A systems innovation approach (SIA) is adopted as the basis of the development and implementation of the MAWGs, as it is particularly suited to addressing the growing complexity and interconnectedness of modern societies and economies by focusing on the functions of a cross-sectoral system as a whole; analyzing challenges, opportunities and designing solutions [16]. Through SIA, it is possible to understand and evaluate the interconnectedness within and among the systems' components that signify decisions, decision-makers, resources, organizational setups, drivers of change, services, and time frames [17].

Among the mechanisms to be used in the framework of SIA are: (i) participatory mapping techniques which will assist the joint examination of the current situation in the river basin, and in the case study area, the identification of actions and management initiatives, existing and hypothetical, that affect WEFE Nexus; (ii) collaborative problem framing and then co-designation of future scenarios with the stakeholders; (iii) validation and analysis of projects outputs; (iv) assessment of the gap to reach future scenarios in terms of local labor skills.

2.2.1. Stakeholders Listing

The first step toward establishing the MAWGs is the identification of appropriate stakeholders to constitute the working group. To do so, a long list of potential MAWG members in the form of sector actors is drafted. This process places emphasis on:

(i) Representation: from all WEFE sectors and sub-sectors as water supply, water quality, water management, hydropower, desalination, traditional agriculture, hydroponics, etc. In addition to sectoral thematic representation, consideration is given to representation within the different categories of the Quadruple Helix model, i.e., public institutions (government agencies, ministries, etc.), private organizations (agri-business, SMEs, etc.),

academia (universities, research centers, etc.) and non-governmental organizations (think tanks, unions, multilateral organizations, activist groups, etc.).

(ii) Alignment: and consistency with the tri-level structure of the AWESOME model in terms of the micro, meso, and macro levels of analysis. The MAWGs are focused on the micro and meso levels, with stakeholders on the micro level being those active within the Egyptian national context, where the demonstration site is located. They are directly relevant to the innovative technological solutions of the demonstration and pilot sites located in Egypt and are engaged in the MAWGs to facilitate the participatory development of mental maps to visualize the key drivers of WEFE change, identification, prioritization, and the valuation of key ecosystem services, capacity building and upskilling. Stakeholders on the meso level come from the three river basin countries (Egypt, Sudan, and Ethiopia), and are engaged to develop the equivalent mental maps from the meso perspective and allowing transferability and adaptability of the WEFE innovations' results, from the micro level to the meso level.

2.2.2. Stakeholders Analysis and Mapping

Stakeholder analysis is crucial in order to gain a deeper understanding, not only of who the key actors are within the WEFE Nexus context but also their perspectives, interests, the relationships to one another, and their relevance to the needs and requirements of the research. The stakeholders identified within the long list are analyzed based on two key criteria:

(i) Influence: the degree to which the stakeholder has the power to effect change, in terms of WEFE Nexus activities in the area of focus.

(ii) Interest: how likely they are to engage in activities and initiatives relevant to the WEFE Nexus and the degree to which they are directly impacted by WEFE Nexus activities.

The stakeholder mapping involves the visualization of the relationships between the stakeholders and the WEFE Nexus, based on their positioning on a graph that plots influence against interest. Such mapping allows the research team to clearly identify where each actor stands when evaluated against the same two key criteria and to compare them to one another. The map is formulated via a participatory process within the case study team and visualized using Miro, an online collaborative working tool. The initial map is then validated by WEFE sector experts, such as members of the project advisory board. Figure 2 represents a sample of the mapping illustrating Interest along the x-axis from low (left side) to high (right side) and Influence on the y-axis from the least influence at the bottom, to the greatest influence at the top.

At present, one year after the project's initiation, 76 stakeholders have been identified at the micro level using the above methodology. Following analysis, they have been grouped based on the four created quadrants, as illustrated in Figure 2.

Monitor/Minimum effort: this is a group of 13 stakeholders characterized by Low Interest/Low Influence, that is useful to be informed only about the big steps of the project and can have a low level of engagement.

Keep satisfied: this is a group of 12 stakeholders characterized by Low Interest/High Influence, which means they should be kept satisfied and updated regularly on projects' output, as their feedback is important.

Keep informed: this is a group of 30 stakeholders with High Interest/Low Influence, that needs to be updated and engaged regularly. While not seemingly as crucial as the Manage Closely or Keep satisfied groups, it is important to solicit input from this group, as it tends to include those who are often marginalized.

Manage closely: this is a group of 16 stakeholders with High Interest/High Influence, that need to participate with a higher level of engagement, as their feedback is critical to any decision-making. This quadrant will serve as a key focal point for the recruitment of MAWG members.

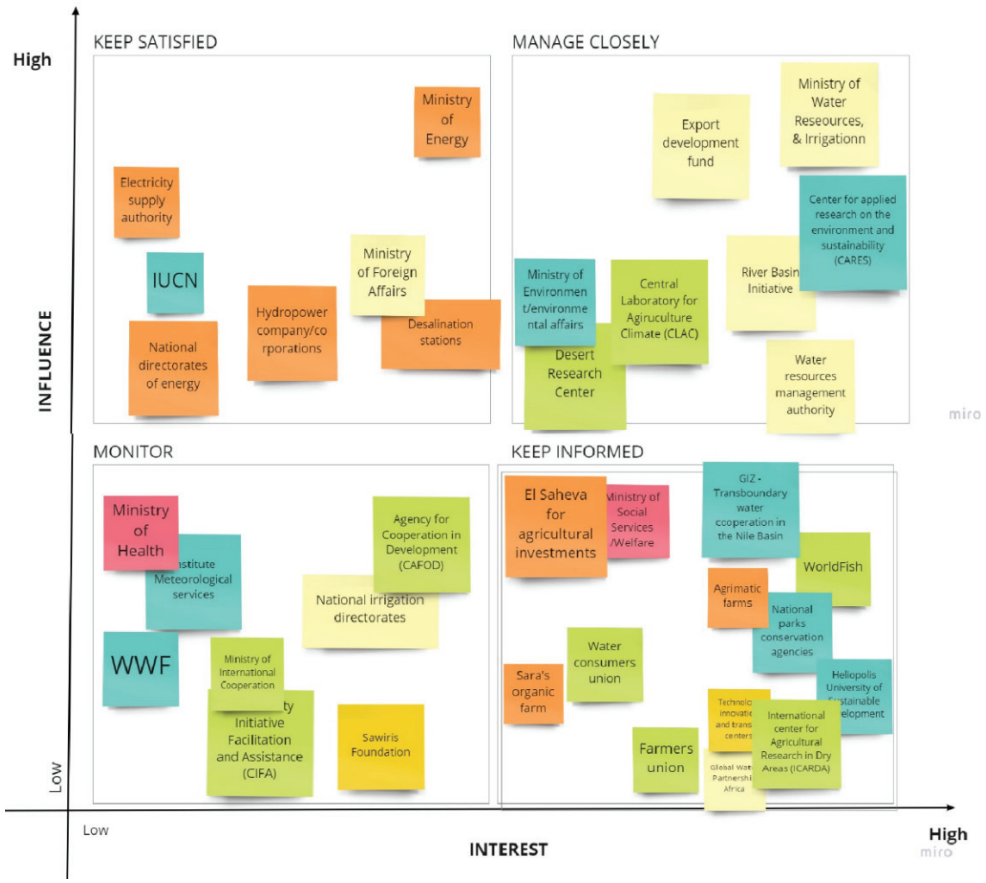

Figure 2. Stakeholders mapping on Miro.

AWESOME's stakeholder mapping process helps mitigate the risk of oversight when selecting potential MAWG members and provides a clear basis for the justification of recruited members.

3. Discussion

The application of the WEFE approach in drought areas, such as the Nile basin, becomes even more significant in the context of COVID-19, as the region faces disproportionate impacts with trends showing over-dependence on energy [18]. COVID-19 has exacerbated the food insecurity that existed in the region in the context of climate change, geopolitical conflict, and economic crises; putting additional pressure on the energy access challenges. Threats, such as reduced access to nutritious food and an increased vulnerability of people with weaker immune systems, mean increased exposure for groups, such as the elderly or people with underlying health conditions [19]. The most prevalent problem that the Nile basin faces boils down to disruptions within the context of the WEFE Nexus; whether caused by a change in demand patterns or changes and shortages in supply [20]. Demand-induced disruption can be linked with a high demand for water for sanitation purposes (such as for hand washing) and increased medical waste (protection materials, such as gloves and masks), both affecting the water sector and consequently the energy demand for water [21], while supply-induced disruptions can be caused by mortality or morbidity impacting the supply of labor in industries, such as food and by a lack of sufficient infrastructure [18]. The Pan African University Institute of Water and Energy Sciences, in a recent study based on an online survey (842 respondents from Uganda, Tanzania, and Nigeria), reports that lockdown policies have already had a negative impact on the production of food since the basic actors in the food supply chain are unable to work; resulting in food prices increasing by more than half [22]. At the same time, declining resources due to climate change and demographic conditions can cause WEFE instability

and impact public health directly or via economic repercussions [18]. Such a situation can jeopardize not only human health and well-being but also key developmental goals (e.g., the Sustainable Development Goals (SDGs)) on the African continent [2].

These recent changes in the context of COVID-19 are incorporated into AWESOME's methodology as an attempt to redefine the notion of WEFE resource security in periods of the pandemic; considering in particular, rural areas suffering from virus-related disruptions and workforce reduction. This is especially vital, given that current research focuses on urban-related impacts from pandemics due to their population density and importance to the economy.

4. Conclusions

Global challenges, such as population growth, demands for increased food production, and the pressures on resources (in addition to issues, such as climate change, soil degradation, water scarcity, and environmental pollution) are on the rise. There is an urgent need to find alternative, sustainable, and reliable ways to secure food supply. Innovative agriculture techniques, such as hydroponics, could provide part of the solution to these problems. This article provides a description of a state-of-the-art methodology for convening MAWGs and its linkage with the research toward smart agriculture and food security policy. The results from the first MAWGs will be produced in January 2022 in the form of mental maps, while the next steps will focus on the realization of workshops on two different levels, a case study and the river basin level.

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Proceeding Paper

Sustainability as an Aspect of Societal Quality †

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Abstract: Sustainability and quality have many connections and commonalities. Conceptually, they are ambiguous and subject to interpretations. They multi-disciplinarily relate to many application areas. Quality relates to products, organizations, people, and societies, whereas sustainability to societies or the entire planet. The development of sustainability and the quality of society take place through the actions and diffusion of people and organizations. Organizations apply sustainability in their business by social responsibility. Problems in sustainability are born from its conceptual ambiguity and broad economic and political interest. The article examines sustainability as a subset within a societal quality, and society as a scale-free network.

Keywords: sustainability; quality; management; social responsibility; conceptualization

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1. Introduction

Various writings, including general newspaper articles, corporate publications and scholarly articles, often deal with quality and sustainability in the same context. These concepts have many connections and commonalities but, conceptually, they remain elusive, and their meanings can vary widely in various sources and relations. In connection with these terms, one can emphasize either the state of affairs, properties, or activities. The word quality can be used as a noun or an adjective [1]. Instead, the adjective sustainable or sustained is used in combination with a noun, for example, plan, planning, or development. The expression of sustained success is also used as an important concept in international standardization as the goal for organizations following the quality management principles [2].

It follows from all of the above that many texts related to our subject are easily confusing and unclear in content, and subject to interpretation. This trend has intensified recently. The ambiguity is further increased when the aspects of management, innovation, risks, and resilience are combined with quality and sustainability in practical situations. Management and innovation come to the fore when quality and sustainability are being realized by the organizations. Sustainable development takes place through continual diffusion of the results of the quality activities, lifelong learning, and innovation of the individuals and organizations in society [3]. In this context, risks are related to the effects of uncertainty [4] including the deficiency of information to understand the situations or events, their consequences, or the associated likelihood. Resilience implies adaptive capacity in a complex and changing environment and relates to toughness and the capacity to recover from difficulties.

Quality is an age-old concept, and its content for professional use has become well established and internationally standardized over the past hundred years [5]. Sustainable development thinking originated in the late 1960s in the context of the meetings of the UN about striving at improving the human environment. The concept then evolved under

the influence of many different parties and finally today embraces almost anything with a wide range of content. As a result, the content of sustainability has become blurred, and related activities have become differentiated and fragmented among many different interested parties, which has also generated widespread economic and political interest and opportunities for influence.

The purpose of this article is to clarify sustainability in a quality context conceptually as well as in practice. In this context, the authors present a broad view of the quality of society and the role of sustainability in this context. The issue is examined from the perspectives of related positive and negative development.

2. Object of Examination

Quality can relate to a wide variety of objects, including materials, physical and intellectual products, people, processes, organizations, conditions, communities, and societies, etc., that are results of the activity of nature, man, or organizations. Quality implies the fulfillment (i.e., satisfaction) of the needs and expectations of all related parties [6]. In this sense, nature, human individuals, organizations, and societies are very different actors.

The concept of sustainability in a professional context had originally been aimed at societies or the entire planet and at their characterization, particularly from the human point of view. The quality of the society is based on all inherent characteristics of society, also including all sustainability aspects. Hence, sustainability is a subset of the quality of society. We have used the terms quality of society and societal quality as synonyms.

3. Conceptual and Substantive Development of Sustainability and Related Concepts

The concept of sustainability has a long and varied history of development; however, it has no general and undisputed definition yet. Therefore, the concept is difficult to understand unambiguously, and its content is vague [7,8]. This has resulted in conceptual and practical problems. In order to understand the issue, we need to go to the roots of the subject and look at the different stages of the development on that basis.

3.1. The Global Drive for Sustainable Development

Worldwide sustainability discussion has its roots in the meetings of the UN General Assembly in 1968–1969 [9–11] regarding the quality problems of the human environment, including air and water pollution, erosion, soil deterioration, waste, noise, and biocides. The problems were seen to be due to the increasing population and urbanization, and in particular, industrialization, heavy industry, mining, and transport. The focus was on the consequences of human activity in the physical and biological environment, leaving out purely natural phenomena. Forestry and fishery were the addressed topics. Human harmful consequent effects were related to man, his physical, mental, and social wellbeing, his dignity, and ensuring human rights. Hence, the goal was to deal extensively with the economic, social, cultural, and health aspects. Since then, the issue was addressed continually in many consecutive UN conferences. Hence, these conferences have then later had a significant influence on the content and interpretation of the concept of sustainability.

The Club of Rome [12] is a high-level informal international think tank forum for the research and planning of the future and consists of notable scientists, economists, business leaders, and politicians around the world. Many representatives of the academic, political, financial, and aristocratic elite ("Committee of 300") have been associated with the activities of the Club of Rome [13]. The Club was founded by a group of like-minded thinkers who shared profound concern for the long-term future of humanity and the planet, and it has been active since the early 1970s. They have addressed a wide range of issues, such as environmental issues, resource adequacy and energy issues as the factors of the sustainable world system. According to their report in 1972, "The Limits to Growth" [14], population and economy do not grow at the same rate, and to survive in the future, humanity must change its direction of development. Applying a cybernetic approach, they presented that population, agricultural production, non-renewable resource depletion, industrial output,

and pollution ultimately limit growth on the planet. If the world system is not made sustainable, a sudden and uncontrollable collapse results. For their aspirations, the key figures of the Club of Rome have also become involved in a wide range of global politics, for instance, by warning about the crises of energy and food and environmental catastrophe, and seeking the New World Order (or One World Government) where zero-growth and population reduction are at its core [13,15].

The UN Conference in Stockholm 1972 [16] published the Stockholm Declaration that defined a common outlook and the common principles to inspire and guide the peoples of the world in the preservation and enhancement of the human environment. It also presented a framework for environmental actions and a long list of recommendations for governments and the international community consisting of the measures designed to safeguard and enhance the human environment for the benefit of present and future generations of man.

Despite the significant efforts of the Stockholm Declaration, global environmental challenges had not been adequately addressed since the Stockholm Conference, although these challenges had increased in many ways. That is why, in 1983, the UN set up a commission independent of the UN, focusing on environmental and development problems and solutions. This Commission, known as the Brundtland Commission [17] or more formally the World Commission on Environment and Development (WCED), defined sustainable development as *social and economic progress to ensure people's healthy and productive lives, but without compromising the ability of future generations to respond to their needs*. This had a clear societal focus from a human point of view. The term sustainability was not yet used as a separate concept in the report.

The Rio Declaration of the UN Conference on Environment and Development, "The Earth Summit" [18], reaffirmed the Stockholm Declaration. At the same time, new principles were defined for an equitable global partnership and cooperation among states, key sectors of societies, and people. The central role of humans was emphasized in sustainable development and their rights to a healthy and productive life in harmony with nature. States shall enact effective environmental legislation, and environmental standards, management objectives and priorities should reflect the environmental and developmental context to which they apply. Environmental impact assessment, as a national instrument, was required for proposed activities, which are likely to have a significant adverse impact on the environment. This also is subject to a decision of a competent national authority. In particular, the conference was frightened of the patterns of production and consumption in the industrial world and the increasing overpopulation of developing countries to save the world.

From 1997, the UN's definition of sustainable development [19] has referred, according to the Brundtland Commission, to development that meets the needs of the present without compromising the ability of future generations to meet their own needs. The Kyoto Protocol [20] created by the UN Climate Change Conferences presented legally binding obligations to reduce greenhouse gas emissions on the basis of the notion that (1) dangerous global warming is occurring and (2) anthropogenic carbon dioxide (CO_2) emissions are driving it.

OECD [21] has been actively involved with sustainable development since the Rio Earth Summit (1992). They also defined the concepts of sustainability and sustainable development in the same way as the UN. The World Bank began to interact with civil society in the 1970s through dialogue with non-governmental organizations around environmental concerns. Later, they especially have promoted corporate responsibility plans based on the UN sustainable development goals, sustainability reporting, and international standards [22].

The UN General Assembly adopted in 2000 the UN Millennium Declaration [23], which defined the Millennium Development Goals (MDGs) and were based on the OECD International Development Goals agreed by Development Ministers in the "Shaping the 21st Century Strategy" [24]. The MDGs aimed at:

1. Eradicating extreme poverty and hunger;
2. Achieving universal primary education;
3. Promoting gender equality and empower women;
4. Reducing child mortality;
5. Improving maternal health;
6. Combating HIV/AIDS, malaria, and other diseases;
7. Ensuring environmental sustainability;
8. Developing a global partnership for development.

Later, the UN Conference on Sustainable Development [25] resulted in a political outcome document that contains practical measures for implementing sustainable development. This launched a process to develop a set of Sustainable Development Goals (SDGs), which built upon the earlier MDGs. In this way, the concepts of "sustainable development" and "green economy" sought to bring together the interrelated concerns of societal development, on the one hand, and the environment on the other. Hence, both development and environmental policies had important implications for human rights. MDGs and SDGs are collections of many various aspects and, hence, they marked a very significant extension in the content of the concept of sustainable development.

The SDGs were understood as a "blueprint to achieve a better and more sustainable future for all" and they were set in 2015 by the UN General Assembly and are intended to be achieved by the year 2030. They are included in the UN Resolution of the 2030 Agenda [26]. The SDGs are an extension of the MDGs and consist of the following goals:

1. End poverty in all its forms everywhere;
2. End hunger, achieve food security and improved nutrition, and promote sustainable agriculture;
3. Ensure healthy lives and promote well-being for all at all ages;
4. Ensure inclusive and equitable quality education and promote lifelong learning opportunities for all;
5. Achieve gender equality and empower all women and girls;
6. Ensure availability and sustainable management of water and sanitation for all;
7. Ensure access to affordable, reliable, sustainable, and modern energy for all;
8. Promote sustained, inclusive, and sustainable economic growth, full and productive employment, and decent work for all;
9. Build resilient infrastructure, promote inclusive and sustainable industrialization, and foster innovation;
10. Reduce inequality within and among countries;
11. Make cities and human settlements inclusive, safe, resilient, and sustainable;
12. Ensure sustainable consumption and production patterns;
13. Take urgent action to combat climate change and its impacts;
14. Conserve and sustainably use the oceans and marine resources for sustainable development;
15. Protect, restore, and promote sustainable use of terrestrial ecosystems, sustainably manage forests, combat desertification, and halt and reverse land degradation and halt biodiversity loss;
16. Promote peaceful and inclusive societies for sustainable development, provide access to justice for all, and build effective, accountable, and inclusive institutions at all levels;
17. Strengthen the means of implementation and revitalize the global partnership for sustainable development.

Some of these very cross-cutting objectives have also differentiated into their own more limited specialist areas, and therefore they have also begun to be overemphasized over others. An example is the climate change area, which was started by the UN climate meetings in the 1990s, and which has become a striking and prominent specific factor also from the point of view of sustainable development. A political body, The Intergovernmental Panel on Climate Change (IPCC) [27], created by the UN, provides policymakers with

information on climate change, its implications, and potential future risks as well as puts forward adaptation and mitigation options. In supporting its work, the IPCC has also initiated extensive international scientific research [28] on the physical phenomena of climate change and their natural and anthropogenic causes and effects.

With international development, the scope of sustainable development has expanded over the years towards a wide-ranging and almost all-encompassing agenda for Planet Earth and humanity [22,29]. For instance, the UN uses the phraseology of "Transforming our world: The 2030 Agenda for Sustainable Development" [26]. In general, the development perspective has been reactive, with special attention paid to existing problematic aspects.

3.2. Sustainability Development as the Target or State of a Society

Previously presented UN-related references deal with the human environment or sustainable development. The concept of sustainability was not used explicitly but it was clearly introduced by World Bank research [30] as *a requirement of our generation to manage our resource base such that the average quality of life we ensure ourselves can potentially be shared by all future generations*. In this context, ideas on the relationship between sustainability and quality were also raised. Development is sustainable if it does not involve a decreasing quality of life on average. The UN's definition of sustainability [19] refers to *(a) use of the biosphere by present generations while maintaining its potential yield (benefit) for future generations and/or (b) non-declining trends of economic growth and development that might be impaired by natural resource depletion and environmental degradation*.

There is no single international standard for sustainability, since this concept is so multidisciplinary and related to a great many different fields and their standards. For this reason, specific international guidelines for sustainability have been developed to be applied in preparing standards for various sectors. This guidance is presented in the document ISO Guide 82 [31]. However, different standards have provided different definitions of the concept, but most commonly in the international standards, sustainability means the *state of the global system, including environmental, social and economic aspects, in which the needs of the present are met without compromising the ability of future generations to meet their own needs*. Here, sustainability is also understood as a feature of society. The sustainability of society is always relative. It is not a question of whether or not there is sustainability, but it is always a matter of degree.

The word sustainability is also sometimes used in everyday language. According to Lexico, the word has two different meanings—the general one and the specific one. In general, sustainability means the *ability to maintain something at a certain rate or level*. As a particular meaning, it highlights *avoidance of the depletion of natural resources in order to maintain an ecological balance*. The word sustainability is etymologically [32] derived from the Latin word sustinere, to hold (from tenere—hold; keep; comprehend; represent; support), and it was regularly used in medieval French. The word sustainable dates back to the 1610s referring to "bearable", to 1845 in the sense "defensible", and dates back to 1965 with the meaning "capable of being continued at a certain level". Sustainable growth is recorded from 1965. Correspondingly, since 1907 sustainability originates in reference to a legal objection. In a general sense, it has been used in economics, agriculture, and ecology since 1972.

Since its early definitions and practices, sustainability has emphasized global scope and human aspects and the action plans of societies at large [29,33,34]. Later, sustainability aspects have also begun to be seen as business advantages and challenges [35], and through it also collaboration with organizational stakeholders becomes emphasized [36]. This is strongly highlighted in the widely referenced and used three pillars of sustainable development [37], which include: (1) economic development; (2) social development (including labor practices, human rights, society, and product responsibility); and (3) environmental protection [38]. Other references in this context are the organizational evaluation and reporting practice of the Global Reporting Initiative (GRI) and the international standard

ISO 26000 for social responsibility [39]. Sometimes the four pillars of sustainability are also mentioned including human, social, economic, and environmental [40]. Other aspects, for instance, culture, may also be added to the pillars of sustainability.

In 2006, the UN Secretary-General launched the Principles for Responsible Investments (PRI) [41], which emphasizes that investment decision-making should sufficiently reflect environmental, social, and corporate governance (ESG) considerations [42]. Therefore, ESG thinking has gained interest especially among companies. Davos Manifesto 2020 of the World Economic Forum, titled by the Universal Purpose of a Company in the Fourth Industrial Revolution, was accelerating the ESG to an organized framework for companies in a new "stakeholder capitalism" approach [43]. This was seen to be in alignment with the UN 2030 Agenda for sustainable development through centering around four key areas: principles of governance, planet, people, and prosperity.

The European Commission's sustainable growth strategy 2020 deals with sustainable growth as a "Green Deal" and defines competitive sustainability through four dimensions: environment, productivity, stability, and fairness. The European Union also has regulations on sustainability-related disclosures in the financial services sector [44], in which the sustainability factors consist of environmental, social, and employee matters, respect for human rights, anti-corruption, and anti-bribery matters. These also increase political pressure and financial opportunities to influence the organizations' asset management and the investors' business.

According to its motto, the International Academy for Quality (IAQ) strives for "Quality for Humanity" and also integrates quality with environmental questions as humanistic applications for society. In fact, this very closely implies the idea of sustainability. IAQ has recently published the new Global Quality Manifesto [45], which unites the IAQ quality professionals of the world to commit themselves to revitalize quality and transform the quality profession to increase its relevance for the world. The IAQ recognizes two critical foundations for quality: the discipline of science coupled with mutual respect for all human beings.

Often, sustainability issues are directly or indirectly linked to social security, societal energy supply, legal safety and protection of the law, and freedom. In addition, many other perspectives and methodological tools [46,47] are considered together with sustainability, including innovation, corporate social responsibility [48], risks [49], and resilience [50,51].

4. Dark Clouds on the Road to a Positive Sustainable Development

The UN Millennium Project was created to implement the UN MDGs, and a large number of global and regional partner organizations were involved in promoting and implementing the goals. Progress was reported annually and significant positive results had been achieved by the 2015 deadline, but the project also learned that further progress will require an unswerving political will, and collective, long-term effort. We need to tackle root causes and do more to integrate the economic, social and environmental dimensions of sustainable development [52].

However, very generally people have got a rather bleak picture of the world through public communication over the last decade. This has related to terrorism, beggary, and deadly epidemics, which have seemed to become worse all the time and lead people to wrongly adopt an overly dramatic, stereotypical, inflexible, and pessimistic worldview. In his famous book [53], Rosling showed with many examples, independently from the UN programs and the general sustainability thinking, that this perception is not correct. In fact, according to him, things are much better than people think. However, it should be noted that often people overestimate the near future and its threats and underestimate distant issues.

Global sustainable development is always influenced by many existing global megatrends, including urbanization (rural-urban migration), disruptive technological development (digitalization), geopolitical contradictions, refugee migrating, multicultural encountering, economic uncertainty and crises, epidemics, natural turbulent events and their

consequences, the relativity of truthfulness, etc. None of these phenomena are completely independent today, but they all interact, and they all also have an impact on the sustainable development of societies. These phenomena can reinforce or mask consistent sustainable development.

As examples, we look here at current problems in sustainable development in more depth from the viewpoints of the COVID-19 pandemic, climate change, and the distribution of wealth. These global issues are very broad and topical and have strong implications for all three pillars of sustainable development. Sustainability is an extensive issue as a concept and as content and also includes these three specific phenomena, which people, organizations, and authorities have experienced worldwide. The SARS-CoV-2 virus and the CO_2 gas molecule have had a big role in global communications as well as in socio-economic connections of societies, and hence, they have strongly affected the operations of private, public, and third sector organizations, and the lives of people, and led to measures where the principles of constitutional states have been relaxed with regard to individual freedom and rights. Many other issues including the economic aspects seem to surge around these two tiny particles in an uncontrollable way. For instance, in this context, the influential parties have been able to guide the development of society with economic factors strongly and in accordance with the intentions of specific ideologies, which can be considered detrimental to positive sustainable development.

The Secretary-General of the UN has paid attention to how the COVID-19 pandemic disease and the related societal interventions have had negative, even dystopian, effects on sustainable development [54] with regard to individual freedom and rights. He brings out many phenomena that have occurred in the field of human rights. According to him, disagreement, vulnerability and inequality have deepened, and new fractures in human rights have been revealed. Women, minorities, persons with disabilities, older persons, refugees, migrants, and indigenous peoples have lived through a disproportionate toll. Young people have struggled and have been directed to distance learning instead of schooling. The vicious circles of violations have been identified all around the world. The heavy-handed security and emergency measures of the authorities have reduced the political and civil rights and civic space by crushing dissent, criminalizing basic freedoms, silencing independent reporting, and curtailing the activities of non-governmental organizations. Human rights defenders, journalists, lawyers, political activists, even medical professionals have been detained, prosecuted, and subjected to intimidation and surveillance for criticizing government pandemic responses. Additionally, electoral processes have been subverted, opposition voices weakened, and criticism suppressed. Access to life-saving information has been concealed, and deadly misinformation amplified. The growing reach of digital platforms has made possible the abuse of data, including information being assembled about individuals without knowing how this information has been collected, by whom, or for what purposes. Data are being used commercially and commodified and sold like futures contracts, and also being used to shape and manipulate our perceptions, without our realizing it. Governments exploit that data to control the behavior of their own citizens, violating the human rights of individuals or groups. The recognized representatives [55–58] of the scientific communities in different countries have also justified and confirmed these adverse phenomena by arguing, referring to data-based analyses, and commenting on measures against the pandemic from political and medical authorities at the national and international level. Many international and national lawsuits have also been initiated against COVID-19 measures taken by various organizations and persons, which have been widely covered in the media [59–61]. In addition, large numbers of people have staged demonstrations around the world against society's oversized measures to control the pandemic (e.g., [62]). In these contexts today, all-encompassing information and communication technology also makes it possible that the different involved parties can manipulate people and circulate false information effectively in accordance with their own purposes. In this case, certain results of science and research can also be falsified or concealed.

Political climate change measures have had wide-ranging societal impacts around the whole planet. The focus has been on global warming, which is alleged to be due to atmospheric carbon dioxide (CO_2) originating from anthropogenic activities. Political decisions of the authorities have had massive repercussions on international and national economic and societal activity and consequently even on the behavior and lives of human individuals. This has even led to declarations of climate emergencies. However, all these measures represent only a small part of the whole area of environmental protection for sustainable development. In the scientific community, this issue has been widely debated [63], and the matter is not unambiguous at all. Deliberate or intentional misrepresentation of scientific results of the practical climate measurements has also been featured in these discussions worldwide. The total amount of CO_2 in the atmosphere is very small, only about 0.04%. It comes mainly from terrain microbes and gas dissolved in ocean water, and its amount follows the temperature of the earth's surface, which is mainly caused by the influence of the sun. Human activity accounts for only about 4.6% of atmospheric carbon dioxide and thus 0.002% of all atmospheric gases. Water (gas and vapor) is the most significant gas in the atmosphere that affects temperature and other weather conditions. In addition, methane's aerobic emissions [64,65] and its decomposition into carbon dioxide also influence the anthropogenic portion of the atmospheric CO_2. The recent studies of the methane cycle point out the fact that there is still a great deal of ambiguity and a need for research in atmospheric phenomena as a whole. For example, current theoretical climate models are not well compatible with empirical measures. Carbon dioxide is a gas with a small heat capacity and thus does not have the ability to heat the atmosphere significantly [66]. On the other hand, CO_2 is a vital factor for the planet's vegetation and will influence its positive development crucially [67]. Despite all this, there are authoritative national and international financial contributions and plans to reduce or compensate for anthropogenic CO_2 emissions, the influence of which on global warming is not justified by one accord, but however is harmful to the functioning of society and also to sustainable development.

The economic development pillar of sustainability has a very central impact on how and to what extent society can meet the inherent needs of its individuals and organizations. One of the core issues is wealth and its distribution and utilization in society, which have been under consideration for centuries [68]. Several SDGs of the UN 2030 Agenda address these aspects, such as SDG 1 (Poverty), SDG 8 (Economic growth, employment, and decent work), and SDG 10 (Inequality). The pandemic measures, as described earlier, have had detrimental effects on economic development through lost jobs, huge mounting debt, and steep falls in income, and rising poverty, and huge economic arrangements. Many big investments for reducing CO_2 emissions have been implemented at the expense of the overall development of the economy and other environmental issues. In general, economic paradigms have varied over time [69,70] from one ideology to another in societies. The paradigms have lent added weight in favor of some solutions and against others. In this case, political extremes often become emphasized, or people want to highlight them in a positive or negative way. For the most part, however, members of society are anything but extremes [53]. When a paradigm ceases to be helpful in understanding the societal phenomena and solving practical problems there is a period of political and ideological turbulence until a successor emerges and structures our political imagination differently. Right now we are living in such a time again. A particular threat, in this case, is that those who hold economic and political power threaten the free and balanced sustainable development of society. When in a difficult socio-economic situation, the indebtedness of households, companies, and states grows too much, and the domination of central banks increases. When the situation is strengthened by the influence of political or elite power and promoted by introducing digital money by central banks, the freedom of action and even privacy of various members of society will be disrupted. This can become dangerous from the perspective of human rights if artificial intelligence applications and a social credit system are integrated into the system [71,72]. Free capital markets are a source of wellbeing [73,74].

Big economic and social challenges are associated with the COVID-19 pandemic and climate change. Hence, the interest of political movements, multinational global institutions, organizations, and influential individuals have been enhanced in order to take advantage of the situation. This includes that the political solutions of governments at the country level and the strategic intrigues of large corporations globally have been strengthened, and wide-ranging power games have emerged. The so-called The Great Reset [75,76] includes the goals of a comprehensive change of the entire world order. This orientation has strengthened recently, for instance, due to the technological opportunities of the 4th industrial revolution, but the phenomenon has long ideological-historical roots [77]. It also involves huge financial stakes and power aspirations, and therefore has received much criticism [78].

5. Sustainability in the Quality of Society

Sustainability has conceptually and in practice evolved over time with the influence of many different parties and, finally today, it embraces almost anything possible and includes a wide range of content aspects. As a result, the issue has become blurred, and related activities have become differentiated and fragmented among different parties, where also they can emphasize the different details according to their own interests. Hence, the effectiveness of the overall development of the topic will also be disrupted. To avoid this all, the following previously mentioned, non-reductionist, and widely consensual standard definition [31] is useful: *state of the society, including environmental, social and economic aspects, in which the needs of the present are met without compromising the ability of future generations to meet their own needs*. This is a compact definition that focuses directly on the core content of sustainability. From a practical point of view, we want to examine here the definition flexibly from the viewpoint of society, where society can mean regional societies as well as the whole globe.

The quality concept is widely used in professional societal and business contexts by engineers, marketing people, business leaders, authorities, civil service officers, lawyers, media, and architects, etc. but it also is an everyday and philosophical concept. Quality belongs to the basic concepts used for characterizing the performance of human individuals, organizations, and societies. When quality is applied to a society, it means [6] the *degree to which a set of inherent characteristics of the society fulfills requirements*. This definition emphasizes the relative nature of quality ("degree") that also highlights its subjective perception. Society has its inherent characteristics that consist of all of its features or attributes. "Requirement" means needs and expectations, which are related to all interested parties [6] of society and their interactions. Future expectations should also be included. Many theories have been developed to understand human needs, which study and classify them for instance from three motivating drivers—need for achievement, power, or affiliation [79].

It is obvious that the concepts of the sustainability and quality of society have many connections and commonalities [80]. Both concepts consist of many various characteristic dimensions of society. The quality of society includes all recognized sustainability factors, especially its core pillars of economic viability, environmental protection, and social equity. Hence, sustainability can be understood as a subset of the quality of society.

Quality is a more well established and broader concept than sustainability, which makes it possible to link sustainability with the extensive professional discipline of quality-thinking. The quality approach also provides a lot of proven managerial and technical tools for sustainable development and, additionally, it emphasizes a focus on human perception of the inherent characteristics of society. The interested parties of society consist of resident and visiting people of the society directly or via different organizations. We have reasoned and conceptualized the "quality society" comprehensively as a concept that implies a society with high quality, or a well-functioning and well-developing society, which is good for all its interested parties [81]. This is the target of sustainability, too.

As the quality of society also consists of many multidisciplinary aspects, it has also led to practices where the many parties have considered, evaluated, or compared the quality of

societies in a fragmented way through many specific aspects, including municipal activities, environment, nature, culture, family issues, feminist issues, migration, employment, education, industry, agriculture, tourism, innovation, welfare, wellbeing, happiness, aging, health, sport, communication, food, security, religion, etc. All of these issues also overlap, at least in part, and there are vague relations between them. This has conceptually confused the quality of society and prevented us from obtaining a clear picture of its practical holistic development. Often, the topic has also been considered from institutional viewpoints and with generally standardized criteria. In this case, the dispersion of the needs and expectations of individuals is not taken into account, which, however, is absolutely crucial for quality. During the past ten years we have been pondering and have developed a systematic approach to categorize the inherent characteristics of society from the viewpoint of human individuals. This consists of the following elements:

- Societal services and their effectiveness and integrity;
- Serviceability (i.e., service accessibility and retainability), including capability and availability;
- Security regarding property, belongings, information/cyber security, societal stability, and local, regional and national defense;
- Human identity and intimacy, privacy, self-esteem, self-actualization, and respect;
- Human rights and equality;
- Morality and ethical performance;
- Social performance (*), including education, creativity, connectivity, interactivity and sharing, and incorruptibility;
- Nutrition, cleanliness and health;
- Esthetics;
- Ecology (*);
- Economy (*) and efficiency and cost of poor quality.

Sustainable development pillars (*) are here included in the concept of quality as the subset.

In order to address the quality of society and sustainability, it is necessary to have a clear understanding of the concept of society. Society is not a system but a scale-free network [81] of independent but interactive actors of distinct identities and development status, and consist of citizens, visitors, institutions, private companies, organizations of public civil service, and the not-for-profit third sector. People have a central role in all societies. Human individuals institute society and the same individuals are influenced and developed by the instituted society [82]. Hence, human aspects are crucial in order to reach a high and sustained quality of society. In this context, we also approach the concepts of good life and quality of life. The countries of Northern Europe in particular are generally described as *welfare societies* [83] with democratic institutional foundation. There is widespread prosperity in these countries, but in its implementation, the state does not necessarily play as great a role as in the *welfare state*. In addition to the public service providers, individuals, companies, and other communities operate alongside or and hence there are non-state-centered ways of organizing the realization of prosperity. If one wants to emphasize the role of people in the welfare society, it would be better to use the term *wellbeing society*.

The interests of society as a whole and of the individual often come to the fore as opposing perspectives in the examination of sustainability and sustainable development. The strength of societal quality is that it focuses proactively and directly on the views and perceptions of individuals.

6. Managerial Aspects

Societal quality and sustainability are the results of awareness and determined measures in the organizations, where individuals can be seen as a singular case of organizations [6]. Professionally this can be achieved in organizations by the business integrated quality management, where sustainability management is a part of it. Conceptually *qual-*

ity/sustainability management can be defined as *management with regard to quality/sustainability* [Ibid.], which should take place both at the strategic and operational levels in the organization. In practice, however, the term sustainability management is not commonly used but social responsibility is preferred instead. When organizations take sustainability as an impressive element in their strategic and operational business planning and realization, international standards [84] and especially ISO 26000 [48] can advise them to apply the approach of social responsibility for their sustainable business models [85,86]. For this, the standard provides guidance and defines *social responsibility* as the *responsibility of an organization for the impacts of its decisions and activities on society and the environment, through transparent and ethical behavior* that:

- Contributes to sustainable development, including health and the welfare of society;
- Takes into account the expectations of stakeholders;
- Is in compliance with applicable law and consistent with international norms of behavior;
- Is integrated throughout the organization and practiced in its relationships.

These activities relate to products, services and processes, and relationships refer to the organization's activities within its sphere of societal influence. One example of such an activity is sustainable procurement, which is addressed in the international guidance standard ISO 20400 [87]. The UN, through its large Global Compact Initiative, also promotes and supports the inclusion of sustainability within corporate strategies and operations [88]. To this end, ten principles have been defined for the topics of human rights, labor, environment, and anti-corruption.

According to the corresponding international management standards, social responsibility and quality management are complementary (Table 1).

Table 1. Guiding principles of social principles and quality management.

Principles of Social Responsibility (ISO 26000) [48]	Quality Management Principles (ISO 9000) [6]
Accountability	Customer focus
Transparency	Leadership
Ethical behavior	Involvement of people
Respect for stakeholder interests	Process approach
Respect for the rule of the law	System approach to management
Respect for international norms of behavior	Continual improvement
Respect for human rights	Factual approach to decision making
	Mutually beneficial supplier relations

Individuals' influence for societal quality and sustainability takes place through self-management, whose challenge is [48]:

- To be aware of one's own mental process and its performance in personal environments;
- To consider situation unbiasedly;
- To act straightforwardly without prejudice;
- To develop continually oneself in practical everyday activity.

The effectiveness of the societal investments and satisfaction to the achievements of the social development can be analyzed with different methodologies and from different viewpoints [89,90].

The methodological traditions of quality professionalism can be of great benefit to organizations in managing sustainability and the quality of society. Sustainability and the quality of society can be analyzed for instance with the Kano model [91]. This can be performed by individual factors taking into account the "vital few, trivial many" principle [92]. For the analysis, measurements are required, which presupposes an ontological and epistemological basis of the related phenomena and through it an appropriate measurement

methodology [93]. Quantitatively, the complex phenomena of the societal characteristics can be examined comprehensively by a vector approach or a demerit system procedure [94].

7. Conclusions

Sustainability has been around for a long time with its many manifestations, and it is still a very topical issue throughout the world and is linked to many contexts. However, its conceptual ambiguity and pragmatic fragmentation due to the development of the subject over several decades and the influence of many different parties has made the subject difficult to unambiguously understand and manage. In this article, we have sought to bring concreteness and practicality to the conceptual and methodological consideration of sustainability through the quality of society based on an established professional quality tradition. In this context, we focus on the needs and expectations of individual human beings, because institutional, ideological, or standardized criteria do not solve the prevailing problems. The essence is on freedom and individualism in perceiving the societal environment. With this approach, we also have the connection of sustainability to the recently revitalized Global Quality Manifesto, whose ultimate goal is the essence of goodness in all dimensions of humanity's experience [45].

Some aspects of sustainability and their interactions have recently come to the fore in discussions, research, and societal contributions. These include, in particular, epidemiological, climatic, and economic issues. These have also been intertwined much with national and international politics, resulting in escalation, confrontation, and power plays, which have also had a disruptive effect on the implementation and utilization of scientific means. As the issue has become a society-wide and worldwide issue, the need to redefine policies and ideologies for society as a whole has emerged. On the one hand, the necessity of creating a new centralized world order, "Novus ordo seclorum" (The Great Reset [76]) has been highlighted, and on the other hand, the necessity of philanthropic pragmatism [69]. These also involve a crisis of confrontation, showing top-down and bottom-up, institutional and human, socialist and liberal, as well as global and national confrontations. The whole world seems to be in a complex state of upheaval, which, however, can also be seen as the starting point for the birth of something new, as has happened through the ages.

The complexity is important for the success of renewal. Creativity and innovation originate in this area, and transition to the new forms of activity is made possible. Operation in a complex situation cannot only be led by rational control and based on fact. According to Ashby [95], a successful operation in complex circumstances requires sufficient ability to accept and manage differences and diversity ("requisite variety"). One can receive the benefit from such effects particularly through the wide range of networks and collaboration.

Often, the modern living environment of people and organizations seems to be desperate. However, as Toffler [96] stated, whenever the situation seems to be the hardest and easy solutions are not seen, it is possible to enter a new, more sophisticated level of performance. In the phases of mankind, we can observe long periods of steady development. They are not associated with great development leaps. Toffler noted about the exceptionally difficult circumstance that this is the era of despair—this is a time of opportunity. Sorokin [97] also confirmed in his time that in spite of all the inherent cruelty and the turmoil of the time, however, we are moving towards a better world. In his view, the current culture already contains in its beginning a toxic virus. The current crisis is due to this secret virus and its continuous evolution. A radical change and transformation should be achieved in our operational attitude and habits in the situation of overly matured systematicity and rationality. This would require replacing the existing modes of operation with better culture and expertise. In this context, the quality of society and sustainability as its component are developing.

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Clean Water and Sanitation for All: Study on SDGs 6.1 and 6.2 Targets with State Policies and Interventions in Nigeria †

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Abstract: Water is a fundamental human need. The United Nations Sustainable Development Goals were made to end poverty, safeguard our planet and guarantee government assistance across the planet. This paper will dissect targets SDG 6.1 and 6.2 comparable to the state strategy and mediations in Nigeria, looking at the frameworks that have neglected to add to accomplishing a fair admittance to protected and safe drinking water for all, neglecting to address the weaknesses experienced by women and children. The lack of access to adequate water, sanitation and hygiene (WASH) in Nigeria has been credited to a huge level of diarrheal and intestinal diseases in the country. The discoveries from this exploration paper show that poor policy making in Nigeria is compounding the difficulties connected with hygiene, water insecurity, wellbeing and security, prompting potential issues like hunger, illness, misgovernance and conflict. To address these issues, Nigeria's administration needs to execute some key policies that reconsider their water availability to guarantee the implementation of SDGs 6.1 and 6.2.

Keywords: Nigeria; clean water; sanitation; health; water; feminine hygiene; poverty; policy; water accessibility; hunger; WASH; sustainable development goals; SDG 6; SDG 6.1; SDG 6.2

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1. Introduction

Nigeria is Africa's richest, most populated country with an economy developing fast at 6.3% [1]. As a signatory of the Sustainable Development Goals, Nigeria, like many other states, has been attempting to execute the SDGs on a national level. While Nigeria has gained some headway in the financial terms as of late, its human resources improvement stays weak because of underinvestment and neglect, ranking 152 out of 157 nations in 2018 [1]. It lags in executing development initiatives like water and sanitation and health, education and food security. Nigeria is known to be wealthy in natural resources, yet it requires the improvement of human resources to take advantage of the higher development potential that it has neglected to acknowledge up until now [2,3].

Sustainable Development Goal 6 and its targets are intended to guarantee human development by guaranteeing access to water and sanitation. Accessibility to safe water and sanitation is a strong determinant of a healthy and productive life, as well as environmental sustainability and human advancement [4,5].

Just like the case in many parts of sub-Saharan Africa, the demand for water in Nigeria far exceeds the supply [6]. Water is generally used for two significant purposes in most rural area in Nigeria: in particular, agriculture and domestic utilization [7]. Among Nigeria's populace of above 203 million individuals, 71 million do not have clean water, and 130 million do not have essential sanitation [8]. While water supply insufficiency is a broad issue in Nigeria and the demand for it is developing consistently, rural dwellers are the most affected [6]. Only 61% of individuals have access to a safe water supply—just 41%

within a 30-min round distance of their home, 31% on the premises—and only 7% have channeled water inside their homes [9].

Nigeria is one of the nations in sub-Sahara Africa whose records on broad access to water supply and sanitation facilities by the citizens remain exceptionally poor [10]. In Nigeria, the lack of access to clean water has gross consequences on financial events and personal hygiene and, thus, puts the health of around 40 million Nigerians in danger [5,11,12]. Nigerian urban communities are laden with the inflexible ascent of vagrant settlements, fully packed homes, the breakdown of garbage removal systems, air and water contamination and insufficient water and sanitation services [10]. With the beginning of the pandemic, WASH has become more essential than any time in recent history. Indeed, even now, an extraordinary larger part of the Nigerian populace relies upon self-effort in meeting their day-to-day water and sanitation needs [10]. This prompts the question, Will Nigeria be ready to carry out SDG targets 6.1 and 6.2 by 2030?

This paper expects to examine and take a gander at the target and objectives set by the United Nations for SDG 6.1 and 6.2 and their effective implementation on Nigerian soil. The subject is examined in a few sections. Following the introduction section, the paper will discuss targets 6.1 and 6.2 and their association with different features of human development. The paper will likewise go over how intently the SDGs are interlinked and how the completion of one SDG or target could help in completing the other. The following section will investigate the progress made by government and international organizations on the water policy in Nigeria. The final section will talk about the major challenges and institutional issues confronting policy reforms and implementation in the water and sanitation sector, followed by the conclusions.

2. Clean Water and Sanitation for All and the Sustainable Development Goals

2.1. Target 6.1

> *By 2030, achieve universal and equitable access to safe and affordable drinking water for all.* (Sustainable Development Goals Knowledge Platform, 2015)

The Sustainable Development Goals have been designed to counter and take care of a sustainable and impartial future for all. Alongside the acknowledgment of fundamental human freedoms, achieving fairness in water and sanitation administration is the principal focus of Sustainable Development Goal (SDG) 6 [13]. Target 6.1 of SDG 6 resolves a vital issue. The issue is the fair accessibility of water. There is a strong emphasis on the principle of "fairness of access", which indicates an approaching issue that should be promptly addressed: the imbalance of access [13]. The rural communities of Nigeria, similar to others in different regions of the world, merit a society where water is accessible in a satisfactory amount and quality for the present and posterity, accomplishing sustainable development [9]. It is incontestable that having access to perfect and safe water, as well as adequate sanitation and sensitization of proper hygiene, could lessen the sickness and mortality brought about by preventable infections and can prompt better health, diminish poverty and increase welfare [3].

Any explanation of a rural water policy should consider that the economic challenge differs from the urban water supply regarding scale, demand, organizations and funds [14]. Water is the associating string that interfaces with varying backgrounds. The effects of the risk and expenses of contaminated water on life and efficiency show the essential role water plays in all societies that try to thrive [14]. Its availability and accessibility influence various parts of society and are fundamental to advancement. It is additionally critical for political stability. The inequality and inaccessibility of water can possibly instigate clashes, hunger, insecurity and violence; hamper economic development and poverty reduction endeavors and create a divided society [13,15].

2.2. Universal Access to Water and Zero Hunger

Target 2.2

> *By 2030, end all forms of malnutrition, including achieving by 2025 the internationally agreed targets on stunting and wasting in children under 5 years of age, and address the nutritional needs of adolescent girls, pregnant and lactating women, and older persons.* (Sustainable Development Goals Knowledge Platform, 2015)

Water and nutrition are connected in so many ways; yet, not many of these interlinkages have been well-comprehended [16]. Water is fundamental for a balanced diet and proper development, and subsequently, clean water accessibility is important to battle hunger and malnutrition. SDG 6 and, thus, target 6.1 are associated with SDG 2. In bringing an end to hunger and malnutrition, safe drinking water is required (SDG 6.1) [17]. Target 2.2 states to end all types of malnourishments, including accomplishing by 2025 the globally concurred targets on stunting and wasting in children below 5 years of age, and address the nutritional necessities of adolescent girls, pregnant and lactating women and older people by 2030 [18].

The pathways from water to nutrition incorporate the arrangement of safe water for drinking and other domestic purposes; water for industrial uses and water of standard quality for irrigation, fisheries and crop production, as well as for farming processing [17]. It has previously been laid out how water is associated with each part of life. Target 6.1 is intensely associated with accomplishing this objective. There are key water–nutrition linkages reflected in SDG 2 (end hunger, achieve food security and improved nutrition and promote sustainable agriculture) and SDG 6 (ensure availability and sustainable management of water and sanitation for all) [16].

For Nigerian's, water is associated with a main part of their lives, agriculture and home use. The accessibility of safe and cheap drinking water is necessary to extirpate malnutrition and hunger. Water that is polluted by synthetic compounds or cannot be transported to various networks or is costly to afford can cause dehydration and stunted growth. This absence of access can likewise cause medical problems by harming the healthful necessities of adolescent girls, pregnant and lactating women and older people. This has a trickledown impact that influences the present, as well as the future fate, of society.

Figure 1 makes sense of the connection between water accessibility and food security and zero hunger. Expanding urbanization, industrialization and population increase, and the resulting expansion in water interest, fundamentally contend with the agrarian water demand [17]. This influences the water accessibility in rural regions. In 2012, the Global Hunger Index positioned Nigeria 40th out of 79 countries, while the 2011 UNDP Human Development Index put Nigeria 156th out of 187 nations [19]. Rural people are, in this manner, compelled to depend on groundwater supplies, prompting leading to various medical problems, for example, cholera, stunting and wasting in children below five. The absence of water additionally influences cultivating and agriculture, causing food insecurity. A terrible harvest season could cause less income from the market, which, in turn, could cause less buying power. Families are consequently food insecure, proportioning their profit and their food.

2.3. Universal Access to Water through Infrastructure

Target 9.1

> *Develop a quality, reliable, sustainable and resilient infrastructure, including regional and transborder infrastructure, to support economic development and human well-being, with a focus on affordable and equitable access for all.* (Sustainable Development Goals Knowledge Platform, 2015)

Target 6.1 and Target 9.1 are inherently associated. To guarantee safe and affordable access to water, fabricating the essential infrastructure is significant. Basically, the framework offers fundamental types of assistance to individuals, such as water and energy, and defends them from dangers, for example, floods or the microorganisms in sewage [20].

Infrastructure, for example, pipes, wells and dams, are fundamental in giving widespread and fair access to clean and affordable drinking water for all, from the thickly populated metropolitan areas to the scantily located rural regions.

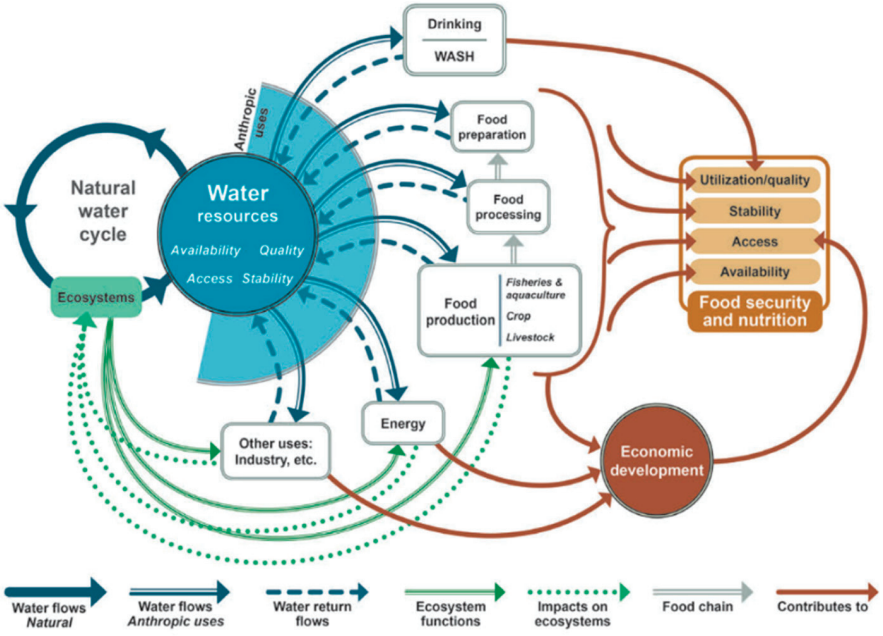

Figure 1. Adapted from Ringler et al. (2018). Water Use and Sanitation. Retrieved from Meeting the Nutrition and Water Targets of the Sustainable Development Goals: Achieving Progress through Linked Interventions. Retrieved from Colombo, Sri Lanka: International Water Management Institute (IWMI). CGIAR Research Program on Water, Land and Ecosystems (WLE); Washington, DC, USA: The World Bank. 24p. (WLE Research for Development (R4D) Learning Series 7), doi: 10.5337/2018.221. p. 10 of 28.

The water framework sector has the biggest direct impact on people, from wastewater and sanitation administrations and infrastructure frameworks to safeguard against flooding, as well as the water supply [20]. A practical framework can give pathways and be in-route to a more noteworthy and more profound availability all throughout the community. With a strong infrastructure plan, it becomes simpler to guarantee the all-inclusive and impartial access to clean and affordable drinking water for all. Consequently, there is a synergistic instrument to convey information between infrastructure systems and the SDGs, with a framework-empowering conveyance of SDG 6, while the targets give a system directing and compelling the arrangement of the infrastructure so it is practical [20]. All of this adds to the supply of water to both urban and rural regions.

3. Water, Sanitation, Hygiene, Gender and the Sustainable Development Goals

3.1. Target 6.2

> *By 2030, achieve access to adequate and equitable sanitation and hygiene for all and end open defecation, paying special attention to the needs of women and girls and those in vulnerable situations.* (Sustainable Development Goals Knowledge Platform, 2015)

Target 6.2 calls for water and sanitation for all and perceives that safe sanitation practice structure a critical component of future social development and economic progress [21]. Great hygiene practices, for example, handwashing with cleanser and water after making use of the restroom and prior to preparing and eating food s, are fundamental for restricting the spread of communicable diseases [22]. In any case, there are many motivations behind why good cleanliness practices are not carried out in the developing world. The causes range from the absence of hand washing amenities to abject poverty to the absence of knowledge and information.

Practices, for example, open excretion, are normal in Nigeria. The absence of knowledge on the dangers of open excretion was observed as a reason for the commonness of open excretion in Nigeria [23]. Open excretion prompts a flare-up of diseases that the public authority needs to contain to forestall the loss of lives [23]. The Water and Sanitation Program (WSP) Nigeria [24] detailed that, because of poor sanitation, NGN 455 billion is lost every year by the Nigerian government [23,24].

It very well may be contended that, in the case of disease outbreak, the economy will probably be disabled, as the Nigerian government would spend more funds containing an outbreak of disease as opposed to utilizing it to work on improving the standard of life of its general population [23]. This is a significant health and gender concern. Practices such as these excessively affect women, girls and children. Children face outrageous health concerns, for example, stunted growth, cholera and diarrhea, through contaminated food and water [23]. Women and girls face security issues as they risk getting assaulted or attacked each time they go out to defecate in an exposed place [23]. It is likewise very unhygienic for ladies to be in these situations and taking a chance with innumerable infections and reproductive issues. The accessibility of clean water and sanitation is important to stay away from illnesses, unexpected health problems and security issues.

3.2. Access to Safe and Affordable Drinking Water and Fighting Waterborne Diseases

Target 3.3

> *By 2030, end the epidemics of AIDS, tuberculosis, malaria and neglected tropical diseases and combat hepatitis, water-borne diseases and other communicable diseases.* (Sustainable Development Goals Knowledge Platform, 2015)

Target 6.2 connects with Target 3.3, battling communicable diseases, "By 2030, end the epidemic of AIDS, tuberculosis, malaria and neglected tropical diseases and combat hepatitis, water-borne diseases and other communicable diseases" [22]. Around the world, nearly 6.3% of the mortality recorded were from unsafe drinking water, sanitation facilities and cleanliness practices [5,25].

The accessible sanitation information in the study area uncovered that open-pit latrines are the most prevalent, accounting for 23.0%, while simple pit latrines are the least 3.3% [5]. This is not just unhygienic but also hazardous. It is estimated that around 122,000 Nigerians, including 87,000 young children under 5 years, die yearly because of diarrhea [5]. The accessibility to safe and affordable drinking water and quality sanitation nullifies the possibilities of being diagnosed to have a waterborne illness.

Hands can easily be polluted with feces, directly or indirectly of oneself or of another [26]. In many parts of the rural settlements in Southwest Nigeria, the issue of water, sanitation and hygiene (WASH) is made worse by the small number of occupants with access to safe water and sanitation [5]. The methodical reviews done from 1997 to 2010 showed that hand washing with a cleanser or soap diminished diarrhea by either 32% or 48% [26]. Washing hands is the most ideal way to forestall sickness yet on the off chance that there isn't any water accessible, how should one forestall the illness?

Indeed, even by most modest approximations, Nigeria is as yet recording under half accessibility to safe water and hygienic method for feces disposal [6]. Tainting of the hands during exercises like excreting and changing/washing of a child's bottom aids in the transmission of diseases [26]. Without hand washing amenities, both the mother and the kid are continually at risk for a disease.

A handwashing and good cleanliness routine avails the benefit of water and sanitation services [27]. The majority of individuals in the rural areas of the developing countries cannot afford to purchase soaps or cleansers for hand washing [26]. The Coronavirus pandemic has recently emphasized this position with specialists over and over underlining the significance of washing hands. The absence of access to clean water influences the susceptibility to sickness and infirmity [27]. While there is no substantial information and the world is as yet attempting to comprehend the virus, water is vital to moderating it.

A decrease in the rate of waterborne sickness and water-related illnesses in rural regions is supposed to reflect a lower patronage of health facilities and lower spending on medications [6]. Having a health infrastructure that is continually troubled by issues that can be moderated through improvement leads to a lack of funds. The reserve funds made through lower spending on medications and clinic patronage can consequently be directed toward other productive endeavors as a significant condition for expanded production and advancement in Nigeria [6].

3.3. Women and Girls and Their Right to Gender Equality and Water Accessibility

Target 5.4

> *Recognize and value unpaid care and domestic work through the provision of public services, infrastructure and social protection policies and the promotion of shared responsibility within the household and the family as nationally appropriate.* (Sustainable Development Goals Knowledge Platform, 2015)

Water, sanitation and hygiene (WASH) are profoundly significant for women's and girls' empowerment, affecting their education, health, income and safety [28]. Target 6.2 recognizes the necessities of women and girls and their right to gender equality. Target 5.4 "Recognizes and esteems neglected care and domestic work through the arrangement of public services, framework and social security approaches and the advancement of shared roles inside the family and the family as broadly suitable [22]". Today, more than two billion people lack access to safe drinking water and basic sanitation services, and a considerable lot of them are women [28].

Target 6.2 is centered around tending to sanitation and hygiene issues for girls/women. Not having to walk a long distance to get water or care for ill family individuals saves women's time, and not having to use a common sanitary facility with different families further develops women's security [22]. In many developing nations, women and children are frequently delegated the responsibility to find and bring water from the source to their homes. Nigeria is no exception. Imbalances in access to water, sanitation and hygiene services have been estimated among rural and urban regions and across country abundance quintiles, as well as by sex [29].

The gender division of roles pushes the duty regarding WASH-related administration onto women and girls [30]. The distance to a water source builds up the time expected for income-producing exercises, family tasks and childcare [5,31]. A young girl is given the duty of providing water for the home while the mother centers around the coordination, including the sanitation and hygiene of the home [30]. Presently, as a feature of SDG evaluation, markers are gathered on access to water on the premises (SDG 6) and the extent of time spent on unpaid domestic and care work by sex and age (SDG 5) [29].

Women's water, sanitation and hygiene needs during their monthly cycle, pregnancy and providing care have consequences for their general wellbeing, education and psychosocial stress [29]. Women should change their sanitary products every now and again, and for those that use reusable products, there is a need for soap, clean water and a good drying space for the reusable towels [26]. Ladies frequently go in groups to the water source to avoid being molested on the way. The absence of private toilets urges women to opt for open defecation, which makes them easy prey to sexual attack and assault, turning into a security concern [30]. Women are unprotected even when they are carrying out the most fundamental of assignments.

Target 6.2 seeks to diminish the differences between genders by bringing to light the difficulties experienced by women in getting water and sanitation. Women are not paid for the responsibilities they carry out in the family, as society thinks of it as their obligation. Numerous young ladies have needed to exit school as they need to get water for their families or need to take part in domestic activities. This gender lopsidedness and absence of chances has created imbalances among communities, and it very well may be tended to and tackled by implementing target 6.2. Better sanitation services and access to water

would empower ladies to have time and resources once again to seek after their education, better wellbeing and earn a decent living.

4. Nigeria's Progress towards Implementing SDG 6.1 and 6.2

4.1. WASH Policies in Nigeria

Access to WASH is exceptionally important for invigorating and guaranteeing economic growth and supporting life and the environment. With the validation of the SDGs, the new aggressive worldwide targets set for sustainable development have been embraced by the Government of Nigeria. In 2015, there were around 60 million individuals without water for their essential use [31]. For sanitation, just 33% of the whole populace had essential sanitation [31]. In November 2018, the leader of Nigeria, President Muhammadu Buhari, declared a state of emergency situation in Nigeria's WASH sector and flagged off the National Action Plan (NAP) to restore Nigeria's WASH sector. The principal objective of NAP is to guarantee that sustainable and safely managed WASH services are available to all Nigerians by 2030, consistent with the Sustainable Development Goals (SDGs) for water (Goal 6.1) and sanitation (Goal 6.2), [9]. The NAP has created a significant open door for Nigeria and is a form of acknowledgment by the Federal Government that the water, sanitation and hygiene sector need earnest consideration, and that an inability to answer the momentum circumstance will have extreme consequences for the country.

4.2. Government

In September 2000, 189 nations from across the world, including Nigeria, embraced the United Nations Millennium Declaration for New York, which prompted the reception of the eight-time bound MDGs and their monitorable markers. The execution of the MDGs in Nigeria started when the Federal Government promising to use the reserve funds from the Paris Club Debt Relief Deal in 2005 for projects and activities designated to help poor people. Various strategies, projects and programs have since been implemented because of reserve funds from the external debt relief, with a direct impact on the MDGs. The federal government regulates water resources; the state government has the essential obligation regarding the urban water supply, and the local government, along with communities, are answerable for the rural water supply [31].

Nigeria has gained critical headway in working on families' access to safe drinking water with an end-point status in 2015 at 67.0% access. The nation is likewise considered to have excelled in this indicator from the statistics of the Joint Monitoring Programme (JMP)/United Nations Children's Fund (UNICEF) and World Health Organization (WHO) showing a recorded end-point status of 69% in 2015 [15]. This contrasts well with the standard figure of 40% in 1990. Notwithstanding, there are wide variations with access to safe drinking water across states, with those in the South having higher access than those in the North. The achievement made in the supply of safe drinking water has, how-ever, not been seen with regards to the extent of the populace utilizing improved sanitation facilities. The end-point status of just 41% using improved sanitation facilities in 2014 is not encouraging, and as a matter of fact, proposes slow progress in this marker. The JMP report is surprisingly more dreadful here, as it recorded 29% for this pointer in 2015.

4.3. International Organizations

Numerous International Non-Governmental Organizations (INGOs) have offered help to the Nigerian government to achieve an expansion in the investment and an improvement in the WASH service to most Nigerians by 2030. The World Bank, the African Development Bank and the French Development Bank have upheld the Nigerian water and sanitation sector for a very long while. As per a United States Agency for International Development (USAID) report, these international donors have supported in the form of more than USD 2 billion of concessional credits to Nigeria beginning around 1979 [32]. Their help has been coordinated for the most part with the development and recovery of a water infrastructure at the state level. Other organizations, for example, UNICEF, have given

direct help to 100 LGAs across 21 states. Essentially, WaterAid has signed a memorandum of understanding with the Federal Government of Nigeria, pointed toward offering technical support, capacity development and policy and strategy development [33]. USAID, on the other hand, is supporting Nigeria to further develop health results through the supply of sustainable WASH services by improving the urban water service conveyance through reinforcing the administration, monetary and technical viability of some State Water Boards (SWBs) [32].

5. Challenges towards Achieving WASH

5.1. Poverty

Poverty involves more than the absence of monetary and useful assets to guarantee a sustainable livelihood, and its signs incorporate hunger and malnutrition, restricted access to education and other fundamental services, social discrimination and avoidance, as well as the absence of participation in decision-making [34]. It has been accounted for that the sluggish advancement in sanitation might be as a result of the "urbanization of poverty", as poverty is increasing in urban areas [35]. Relocation to urban regions, bringing about a thick cluster of poverty, represents a test for sanitation frameworks that were not initially designed to serve many such families, assuming that they existed by any means. Due to poverty, communities find it hard to use the only accessible soap at a household for hand washing [26,36]. Likewise, hand washing facilities utilized subsequent to visiting a toilet are typically not long-lasting, as they are produced from materials that are not solid [26]. There are three primary obstructions to the progress of urban services in ghetto areas: Firstly, lacking supply, particularly of arranged services. Furthermore, there are generally request requirements that prevent individuals' access to these services (for instance, because of a low ability to pay). Thirdly, there are institutional limitations that keep the poor from gaining sufficient urban services [37].

5.2. Lack of Infrastructure

National government planning and evaluation endeavors, as well as post-project monitoring by NGOs or scientists, have highlighted the failure of water supply systems (including water points, wells and boreholes) and sanitation systems as significant difficulties. The technical difficulties (e.g., poor provincial preparation and logistics issues) to give fundamental water and sanitation services to discriminated populaces are dialing back on the off-chance of not forestalling by and large the comprehensive water and sanitation improvement endeavors [13].

Many water and sanitation systems are unsustainable, neglecting the health needs of communities over the long haul. This has been credited to monetary expenses, deficient technical training for tasks and maintenance, bad utilization of new facilities and an absence of local investment and proprietorship [38]. Access to WASH services likewise differs within countries as regards to the socioeconomic status, political power and level of urbanization. A 2004 report by UNICEF expressed that urban households are 30% and 135% bound to have further developed water sources and sanitation, respectively, as contrasted with rural regions. New megacities in the developing world have exponential population growth and are unable to keep pace with the population growth in term of the needed infrastructure [39].

5.3. Misgovernance

Good water management is a fundamental point of support for executing SDG 6. However, administrative structures will generally be powerless and divided into numerous nations, including Nigeria. Good water management gives the political, institutional and managerial standards, practices and procedures for decision-making and executing them. Governments have responsibility for many governance functions, for example, formulating policy, creating legal systems, planning, coordination, funding and supporting, capacity improvement, data acquisition and monitoring and regulation.

Be that as it may, water governance is progressively moving past the government to different partners, including the private sector. Good water governance contains numerous components; however, it chiefly incorporates viable, responsive and accountable state institutions that respond to change; receptiveness and straightforwardness furnishing partners with data and giving citizens and communities a say in decision-making. Cooperation and multi-partner commitment are significant pieces of policy processes, despite the fact that estimating their adequacy is still in its earliest stages. The significance of having a transparent, universal and impartial stage for government and citizen groups set up to prepare accessible water resources and look for a better method for guaranteeing further developed water services was shown to be fundamental and correlative to the local government support. The significance of the capacity turns into a vital component in how a policy is made and implemented [40].

5.4. Lack of Proper Data

Data support the administration components of accountability, transparency and participation. They make it possible for progress to be observed and service providers, governments and development partners to be considered answerable. Many nations, including Nigeria, come up short on monetary, institutional and human resources to ascertain the information to help water governance. Less than 50% of the UN member states have similar data accessible on the progress towards meeting each of the SDG 6 targets. Stakeholders have no business testing the authenticity of inaccurate or one-sided positions without accessible data. Dependable, consistent and, whenever the situation allows, disaggregated information is fundamental to animate political responsibility, illuminate policymaking and independent direction and trigger all-around investments towards health, environment and economic additions. Progress is being made to harmonize data and reporting; yet, the primary and procedural issues rise out of the national level in policy, planning, finance and management, which give a few reasons with respect as to why rural water has not been generally viewed as an organized system of rural water points [14].

Information securing and evaluations require a political obligation of transparency that incorporates the endeavors connected with availability and the sharing of information. Expanded usage of the most recent Earth observations, citizen science and private sector data ought to be integrated into the data evaluating frameworks at all levels to complete the existing information gathering endeavors [40].

5.5. Climate Change

Environmental change presents an expanded hazard to WASH systems, especially in Sub-Saharan Africa, where access to securely oversee essential sanitation is low [41]. In many Sub-Saharan Africa nations, including Nigeria, an ineffectively handled WASH system and large rural settlements with restricted access to water and sanitation systems are particularly helpless against severe environmental conditions, for example, flooding [42]. Changes in the recurrence and force of severe environmental conditions could probably affect different WASH factors and water accessibility. For instance, flooding can influence water treatment, water sources and sanitation, while drought might influence water sources, hand hygiene and water storage [43].

6. Conclusions

In conclusion, Nigeria has a lot to do before 2030. The nation has implemented policies, for example, the National Action Plan (NAP), for the rejuvenation of Nigeria's WASH sector; however, it is, by all accounts, a bit late. There is a notable part of the populace that is as yet attempting to accomplish universal access to water in both urban and rural regions. While there are plans set up to guarantee a fast execution of SDG 6, with the development of the pandemic, it appears to be that there is still a significant step to be taken. A significant framework expected to improve the water availability and sanitation accessibility presently is yet to be made. Recent assessments have shown that only 33% of the complete populace

of Nigeria has access to essential sanitation [31]. That is a very unsettling number. Various sanitation projects have become unreasonable because of funds, insufficient technical know-how for tasks and maintenance, the absence of capacity, the inappropriate utilization of new facilities and poor ways of behaving and an absence of community cooperation and proprietorship [38].

Indeed, even before the pandemic, the nation was battling to carry out SDG 6, targets 6.1 and 6.2. It is burdened with difficulties like an absence of funds, poverty, political instability, bad governance and dishonesty. Inadequate provisions of organized services, a thorough approach, constraints that hinders an individuals' access to these services (for instance, because of a low eagerness to pay) and institutional limitations keep the poor from gaining sufficient urban services [37].

Access to WASH is profoundly vital for invigorating and guaranteeing socioeconomic development and supporting life and the environment of any country. Every one of the sustainable development goals has been intended to supplement and work with the execution of the others by giving a particular structure. As this paper illustrated, WASH is related to the health, development and economic growth of a country. Water is inherently related to the health and prosperity of the country. While Nigeria has absolutely made a few enhancements in further developing its water access and fairness, there is a lot to be finished. It appears to be improbable that the nation will hit targets 6.1 and 6.2 by 2030; however, assuming the government and international organizations make a few unequivocal strides and carry out a local area-centered ground-up strategy, there is hope for development ahead.

7. Recommendations

Here are just some of the recommendations that are made to move Nigeria towards achieving SDG 6.1 and 6.2:

(a) Governments at all levels need to work with the key stakeholders in WASH to improve the local water governance.
(b) There is the need to reinforce the capacity of the local and national authorities to manage and control sanitation systems, including the improvement of data management frameworks.
(c) Rank water efficiency as very important across activities by introducing the best practice technologies for water preservation in regions where the water is insufficient.
(d) Guarantee that the voices of women and girls, who the most affected by the lack of WASH services, are acknowledged in water and sanitation plans of action.

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