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Sustainable Rural Development

Strategies, Good Practices, and Opportunities II

Edited by
Ana Nieto Masot and José Luis Gurría Gascón

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Cover image courtesy of Ana Nieto Masot

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Preface

The abandonment of rural areas and the increasing population density in urban areas is a social trend that has been occurring for decades in both developed and developing countries around the world. Urban areas offer greater opportunities for employment and activities, making them more attractive places to move to. This is also promoted by the scarcity of job opportunities in the rural world, which in most cases, has not adapted to the new market economy. This has led to the depopulation of many rural areas worldwide.

Due to this problem, new policies and actions have arisen, promoted by both public authorities and businessmen, to introduce new strategies to achieve sustainable economic development in these rural areas and to resolve the problem of depopulation.

This book, which consists of 26 articles written by research experts on their topic of interest, reports the most recent research in strategies for rural development. This includes case studies from different disciplines and territories; contributions from economic science, geography, anthropology; and research on different areas in Europe, America, and Asia. This book is the second edition of another Special Issue of the Land magazine that was published in 2021 and which featured 16 papers with the same objective: to show sustainable rural development strategies that can offer new opportunities and success stories for these territories.

Ana Nieto Masot and José Luis Gurría Gascón
Editors

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Editorial

Sustainable Rural Development: Strategies, Good Practices and Opportunities (Second Edition)

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In 2021, a book entitled "*Sustainable Rural Development: Strategies, Good Practices and Opportunities*" was launched as a compilation of 16 papers and published in a Special Issue of the journal *Land* [1]. In 2022, a Second Edition was launched, thus confirming the scientific interest in an essential topic: sustainable rural development and strategy design necessary for the stability of a population and the integrated use of resources and environmental conservation in these areas [2–4]. Above all, it is a scientific, social and political challenge that will require short-, medium- and long-term strategies. The situation of rural areas and their prioritized dedication to the agricultural sector are in a critical situation [5], despite its importance, both in the most developed regions and in other developing regions of the world [6–9].

The unequal distribution of land and its production, low incomes and chronic underemployment with a continuously declining and very little diversification, have led to massive emigration and the abandonment of rural areas [10,11]. Rural areas are suffering deterioration or regressive demographic dynamics because they show high rates of ageing, masculinization or low demographic growth [12–14]. In fact, the rural population, very stable for centuries in the context of an agrarian subsistence economy, is emptying of its population, with residents migrating to cities that centralize facilities and services and provide access to employment in and income from the industrial sector [14,15]. The abandonment of traditional forms of habitats and ways of life, and, in the long run, the dismantling of services and facilities, the deterioration of infrastructures or environmental and heritage abandonment [16,17], is causing a multitude of small settlements throughout the territory to disappear and give way to territorial disarticulation [18].

This process of urban concentration, particularly in Europe and the more developed regions of the world, as well as developing areas of Asia and Africa, has led to the depopulation of vast rural regions, with consequent negative economic, social and environmental impacts [19–21].

Due to an awareness of these problems, different programmes are being developed for the revitalisation, recovery and stabilisation of rural environments, both from a global and sectoral perspective at different levels [22], as in the case of European Union Cohesion Policies. This Cohesion Policy has been proposed by the EU since its beginnings and promoted in recent decades in different agreements [23–26] with the aim of achieving sustainable and balanced development in all its territories due to the fact that there is an unequal pattern of territorial occupation, as urban areas, especially large cities, continue to house a majority of the population while a considerable number of rural areas, located in remote places or far from urban centres, are in progressive demographic decline [9,10]. The EU also promotes a territorial policy with a polycentric system of networked medium-sized cities, capable of offering services, employment and income not only for their inhabitants but also for those within their rural surroundings, thus contributing to the stabilisation of the latter population [23,27,28].

These problems include the risks of poverty and social exclusion, difficulties in preserving natural and cultural heritage, and a limited response to the impact of globalisation,

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climate change and other environmental risks [29–31]. Hence, in addition to communication networks, traditional transport networks are also important for facilitating accessibility from rural areas and integration into national and international economic circuits.

For decades, EU policies have been based on a system of specific aid for rural areas, with the particular aim of boosting the agricultural sector for the sake of social and economic cohesion in rural areas. From the outset, the Common Agricultural Policy (CAP) has contributed to improving farmers' incomes and food supply in Europe [32], along with subsidies for rural development through EAFRD aid or through specific programmes such as the LEADER Initiative, where the main objectives are to improve the quality of life in rural areas with the aim of diversifying employment and income and fostering the participation of local stakeholders, inter-territorial cooperation, the redistribution of financial resources and the enhancement of endogenous heritage [29,33].

Fifty-one manuscripts were submitted for consideration for this Second Special Issue, and all of them were subject to the rigorous *Land* review process. In total, twenty-five papers and one case report were finally accepted for publication and inclusion in this Special Issue. The contributions are listed below.

In this regard, several articles are presented in this edition on the different effects of these European rural programmes, the LEADER Initiatives, especially in the less developed countries of the south and east. Rural development is intended to be endogenous, sustainable and participatory and made possible through specialisation and social and technical innovation (new technologies, networks, smart villages, agro-industry 4.0, etc.). Although they have undoubtedly contributed to this and have generated a certain economic and business dynamism, they have not had sufficient economic capacity to achieve their intended objectives. Their results have been very uneven, as mentioned in two articles on Spain and Romania, which state that many projects have been located in the most developed and populated rural areas or in the most urbanised areas [1,2]. Most of these LEADER programmes have been oriented towards rural tourism, with application to different territories and mixed results. Although tourism is not a unique solution, the EU encourages its complementarity with other economic activities, and there are examples of success, as shown in some of the articles presented in this edition (in Spain and Italy) [3,4]. In any case, it cannot be an exclusive alternative to the agricultural crisis, nor can it, in itself, be a driving force for rural development. However, it can become an important resource within a system of complementary multi-sectoral incomes if this possibility exists.

Also of interest are the various papers that reflect China's resolute medium- and long-term rural development policy over the last few decades. First, we mention the paper that analyses China's national strategy with the design of rural development plans that promote agricultural and agro-industrial development, food security, culture and heritage, environmental protection and poverty eradication and make rural areas more attractive in 2050, avoiding urban agglomerations [5]. Other papers present complementary strategies by promoting the design of new territorial planning, first, through the construction of specialised agricultural villages, and in other cases, through human settlements using geographical and economic factors to overcome poverty, achieve economic revitalisation, guarantee the sustainable use of farmland and food production and promote network integration for the optimal exploitation of resources [6–9].

Other measures, such as financial support, primarily through the rental of agricultural land, have profoundly improved rural livelihood strategies and incomes, especially for low- and middle-income households [10]. Also, agricultural credit and insurance introduce new technologies in rural areas, such as innovative seeds that will improve the economic performance of these farms [11] or the modification of grain subsidies that were used to support increasing farm sizes [12]. Last but not least, the economic compensation of organic production not only promotes sustainable use and food production but also increases the income of the farmers who are implementing it [13]. On agricultural issues, we mention another work on the diversification of the distribution of vegetable crops and their relationship with the development of urban centres because, through grouping techniques implemented in a GIS, concentrations of different products are detected in some agricultural areas to the detriment of others [14]. Continuing with the primary sector, another work presents the advantages that are being produced in certain areas of China; solutions based on nature and traditional pastoralism reflect better results in the conservation and development of gainful areas [15]. In the attempt to diversify economic activities, there is another paper related to resilience tourism and decision-making [16].

Another focus of the papers published is on different environmental protection figures and the design of strategies that link conservation and sustainable economic and social development. In general, this is a controversial issue, which tends to generate tensions among rural collectives due to the limitations it imposes, sometimes resolved with mediators (such as in the case of the biocultural landscape of the Sierra Occidental de Jalisco, Mexico) [17]. Within this thematic issue, there is a mentioned paper from Nepal [18] that contains the design of new strategies for the improvement of tourism in protected areas. The strong growth of tourism has the disadvantage that it provokes unbalanced development and unequal benefits among the peoples of the park; thus, there is support for an optimal design that balances the development of all the territories because not all the inhabitants and populations participate in its benefits to the same extent. Another paper analyses two national parks in Spain and Italy [19], where the inhabitants of these protected areas perceive that they do not have any positive impact as a result of the socio-economic and land-use restrictions and incompatibilities they impose. Instead, they attribute depopulation to other factors such as transport and isolation or the lack of services and employment. This requires raising awareness and training of human resources working in rural areas. Another study shows the results of the impact on four sites protected by the Natura 2000 network in Spain [20] in the rural areas where they are located, concluding that EPs are not detrimental to depopulation but that the management of these spaces should increase the promotion of tourism and greater compatibility of land uses, including housing and infrastructure development. While the Natura 2000 sites assessed certainly have the scope for tourism promotion, their lenient legal regimes make it largely unfeasible to extend land-use compatibility without damaging protected features. In accordance with this line, mention should be made of the paper that analyses the visual impact of certain buildings in rural settings, how they can affect the quality of the landscape and how they can damage the tourists' view of these sites [21].

An additional thematic axis refers to citizen participation and governance, which should be vertical (integrating all levels of government for the coordination of their investments) and horizontal (integrating all local sectors and actors for the design, development and bottom-up management of any project), and this is discussed in a research work on rural tourism projects implemented in the SW of Spain [22]. Another paper points to the role of agents in social innovation in rural areas in the generation and management of opportunities, capacities and needs, as analysed in different areas of Spain and Scotland [23]. In short, it is essential for rural areas to develop a social dynamism that they lack, enhancing the role of social agents and partnerships.

Finally, we would like to highlight three works that mention new strategies, such as the positive positives that are producing a coworking network in peripheral and non-peripheral areas of Germany, with the possibility of generating socio-spatial models on an international scale [24]. In Poland, optimal results can be obtained from the development of pedestrian and bicycle infrastructure that connect villages with the existing railway network, characterised by a high frequency of trains, in order to revitalise these areas [25], or from the case report above on multiple crops in Bangladesh with the aim of increasing soil improvement and economic yields sustainably [26].

On a global scale, a demographic and social crisis is occurring in rural areas due to depopulation, in other words, the people's abandonment of their populations when migrating to urban areas in search of better job opportunities, services and living conditions. This process is particularly marked in the more developed countries and in continents such as Europe. New lines of research in many social and scientific areas can help to study, analyse and propose new strategies to reduce these processes and convert rural areas into more attractive spaces with greater opportunities so that the population does not migrate to urban areas.

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

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Case Report

How Does Maize-Cowpea Intercropping Maximize Land Use and Economic Return? A Field Trial in Bangladesh

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Abstract: Cultivating multiple crops together can provide numerous benefits, including improved soil health and crop yield. The objective of our study was to determine the optimum planting techniques in intercropping systems, and to maximize their benefits by mitigating competition for resources such as land, space, light interception, and nutrition. The performance of successively planted maize (*Zea mays* L.) grown with cowpea (*Vigna unguiculata* L.) was evaluated with a field trial in Bangladesh. The treatments in our study were: (a) sole maize, (b) sole cowpea, (c) crops sown simultaneously, and (d) crops sown with different time lags (1, 2, and 3 weeks) between the maize-sowing and cowpea-sowing dates. Data on the crops' physiological parameters were recorded. These included light interception, leaf area index (LAI), Soil Plant Analysis Development (SPAD), harvest index, and yield. Simultaneously, canopy coverage was measured using camera-based photo analysis. In addition, an economic analysis of intercropping maize with soybean or cowpea was conducted using gross margin analysis and benefit-cost ratio. In our results, the below-canopy photosynthetically active radiation (PAR) was significantly higher in intercropping treatments when maize was sown three weeks after cowpea. In contrast, the LAI value of the maize and cowpea was significantly greater when sown on the same day than in other intercropping treatments. As a result, the maize yield reduced when intercropped with cowpea. This reduction maximized when both species were sown simultaneously due to higher competition for resources, including nutrients and light. Intercropping was more beneficial in terms of land equivalent ratio than both sole cropping of maize and cowpea, especially when maize was planted three weeks later. However, this benefit was not retained when calculated as maize equivalent yield since the contribution of cowpea was small in the overall maize yield, suggesting the importance of the relative economic value of the component species. Among all treatments, the lowest maize equivalent yield (6.03 ± 0.14 t ha^{-1}) was obtained from sole cowpea, and the largest land equivalent ratio (1.67 ± 0.05) was obtained from intercropping with maize sown three weeks after cowpea. This treatment provided a net income of USD 786.32 $\pm$ 25.08 ha^{-1}. This study has shown that together, maize–cowpea intercropping with a temporal niche difference of three weeks may be a better option for sustainable crop production in Bangladesh, maximizing land use. However, it may not provide a significantly greater maize equivalent yield and economic return.

Keywords: land-use optimization; legume plant; competition; above-ground resources; sustainable agriculture; food security

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1. Introduction

Attaining food and nutritional security for millions of people worldwide is one of the most stressful challenges, particularly for densely populated countries, such as Bangladesh [1,2]. Climate change often creates additional threats to agricultural production. Since it is one of the most vulnerable countries to flood, drought, and sea-level rise [3]. Crop diversification can improve soil fertility and water-use efficiency, and maintain natural enemies of insect pests, while a monoculture system with a single species (rice as in case of Bangladesh) often accelerates nutrient mining from a particular soil layer and hosts pathogenic microorganisms. Moreover, a diversified cropping system is not only a resilient and sustainable crop production technique [4,5] but it also provides large varieties of food with different nutritional qualities [6–8]. Intercropping is a well-known practice of diversified cropping systems and therefore, it could provide similar benefits. For instance, it can efficiently use growth resources, including nutrients, light, and water, thus maintaining soil health [9]. Moreover, the chances of getting yield from at least one of the component crops, even under adverse climatic conditions (e.g., cyclones), is higher than monocropping. Therefore, it has been reported that intercropping could provide a stable yield from the component species [9,10]. However, competition between component crops for resources can significantly reduce yield. Thus, it is an important determinant for selecting component crops in intercropping systems since species diversity can reduce resource competition [11]. For instance, intercropping is more productive and economical when both crops differ in genetic makeup, photosynthetic pathways, growth habit, growth duration, and demand for different growth resources [12,13]. Therefore, intercropping can only provide a yield advantage over sole cropping if the component crops use natural resources in complementary ways [14–16].

Cereal–legume intercropping is an important agronomic practice in which the system's efficiency is superior to the individually grown component species [17–19]. For instance, maize (*Zea mays*)–legume intercropping has multiple benefits over sole cropping and intercropping practices than other species [20–22]. These benefits may have been achieved through symbiotic associations and complementarity interactions between species in harvesting limited resources [10,14,20]. When maize is planted as a wide-spaced crop, it encourages weed infestation and intensifies crop–weed competition [21,22]; meanwhile, there remain unexplored opportunities of getting a harvest from the free space. Growing a component crop in between lines of maize can substantially reduce weed growth. The benefits can be even greater when a legume is selected as a component crop since it can supplement some of its fixed nitrogen to other component crops [19,23]. Moreover, maize and legumes may uptake nutrient elements and water from different layers since their root architecture and penetration depth are different (relatively shallow vs. deep in maize and legume, respectively). Thus, there is less competition between species [23–25].

Maize can be potential cereals for multiple reasons since it provides several outputs, including food and fodder. The demand of maize in Bangladesh is increasing since it is used in animal feed as well as in different food items. In 2018, the demand was 4.48 million tons while the production was 3.28 million tons from ~400-thousand-hectare lands [26].

Considering the diversity of each species, there can be positive interactions when maize and legumes are grown together. For instance, Dong et al. [27] reported a relative advantage of maize–legume intercropping over sole cropping and intercropping of maize with other species due to interspecific facilitation by processes of N_2 fixation, N transfer, and increased resource availability. However, there can still be significant competition for resources when component species are grown simultaneously [28]. There are several potential means to reduce competition, including (a) reducing the plant population density (widely sown maize and legume plants), (b) creating a difference in resource demand (sowing maize and legume at different times), and (c) managing the optimum growing conditions through agronomic practices (e.g., canopy pruning of dominant species) [29].

A temporal variation in cultivating component species, commonly known as "temporal niche difference (TND)", may provide a greater relative yield than simultaneous cultivation since there is a scope for the complimentary use of resources in time [16,28,29]. A recent meta-analysis using maize–soybean intercropping systems showed that TND was more advantageous than simultaneous intercropping. There was a positive relationship between TND and intercropping performance (e.g., land equivalent ratio) [16]. Maize, considered as an exhaustive crop that requires a relatively high input, may induce significant pressure on legumes if planted simultaneously. On the contrary, planting maize after a legume (e.g., cowpea, *Vigna unguiculata* L.) may allow the legume to obtain complementarity utilization of space and the biological nitrogen fixation from legume plants [11]. However, it should be highlighted that lately, sown maize (i.e., sown at the start of the summer season) may sacrifice its yield due to unfavorable conditions, such as relatively higher temperatures.

Until now, few studies have been conducted to examine the relative yield advantage of intercropping when maize and cowpea are sown at different times. Therefore, it is important to investigate whether TND provides a net advantage over sole cropping and simultaneous intercropping through the late planting of maize in maize–cowpea intercropping. Here, the authors examined the performance of maize and cowpea grown in row-intercropping with maize that was sown at different sowing dates. The authors hypothesize that intercropping under TND results in higher resource use efficiency of the component crops (maize and cowpea) and raises the overall economic return than simultaneous intercropping and sole cropping.

2. Materials and Methods

2.1. Study Site

Our experiment was conducted from December 2018 to May 2019 at the Research Field of Patuakhali Science and Technology University in Dumki, Bangladesh (22°27′51.93″ N, and 90°23′14.09″ E). The experimental field belongs to the agro-ecological zone of AEZ–13 [30]. This region occupies an extensive area of tidal floodplain land. The area lies at 0.9 to 2.1 m above the mean sea level [31]. The experimental field is on medium-high land with a soil texture type of silty clay loam. The main mean soil properties (0–15 cm) of this experimental field are: pH = 8.4 ± 0.3 (water, 1:10, m/v), organic matter content = 1.82 ± 0.61%, total N = 0.14 ± 0.07%, exchangeable K (meq per 100 g) = 0.30 ± 0.09, and available P (Olsen-P): 3.3 ± 0.4 mg kg^{-1} soil. Annual precipitation is 2200 mm. The maximum and minimum temperature ranges were 24.5–29.6 °C and 13.9–21.5 °C, respectively, during the cropping period. Relative humidity ranged from 61.0 to 70.6%. The monthly average weather data is presented in the supporting information (Table S1).

2.2. Experimental Design

The experiment consisted of the following six treatments: T_1, sole maize with 60 cm × 20 cm spacing; T_2, sole cowpea with 30 cm × 10 cm spacing; T_3, maize–cowpea intercropping with simultaneous sowing; T_4, maize–cowpea intercropping with maize sown 1 week (wk) after cowpea; T_5, maize–cowpea intercropping with maize sown 2 wks after cowpea; T_6, maize–cowpea intercropping with maize sown 3 wks after cowpea. The spacing for intercropping was similar to sole maize (i.e., 60 cm × 20 cm). The treatments were assigned following a randomized complete block design (RCBD) with three replications. Altogether, there were 18 plots in this experiment, and each replication is considered as a block (Figure S1). Each block was divided into six-unit plots of 3 m × 2 m in which treatments were applied at random. Both blocks and plots were located 1 m apart. The photograph of the field trial and the scheme of the plot design are shown in the Supplementary Materials (Figures S1 and S2). The authors used a hybrid variety of maize (Don-111), whereas indigenous cowpea seed was collected from the Patuakhali Science and Technology University Farm. Fertilization was conducted according to recommended protocols established by the Bangladesh Agricultural Research Council (BARC, 2015). The maize-grown fields (either sole or intercropped with cowpea) received 120, 60, and 40 kg ha^{-1} of N, P_2O_5, and K_2O as urea, triple superphosphate (TSP), and muriate of potash (MoP), respectively. The urea was applied in three equal splits at 25 and 60 days after sowing

(DAS) during land preparation. Sole cowpea received 20, 40, and 20 kg ha^{-1} of N, P_2O_5, and K_2O as urea, TSP, and MP, respectively. Soil moisture was maintained at 70% field capacity with several irrigations, and plant protection measures were enforced when necessary.

2.3. Data Collection

2.3.1. Light Interception and SPAD (Soil and Plant Analysis Development) Value

The light interception was measured just before the maize flowered (75 DAS) using a ceptometer (AccuPAR, model-LP-80, Decagon Devices, Inc., Pullman, WA, USA). Specifically, above- and below-canopy PAR (photosynthetically active radiation), and leaf area index (LAI) were measured by taking four readings for each measurement. These four readings were taken from four locations on a plot. These measurements were taken in the middle of the rows and lines of crops, as there can be possible variations in PAR values as the distance between lines (60 cm for maize) and rows (20 cm for maize) changes. The chlorophyll content of leaves was measured using a SPAD meter (SPAD-502 plus, Konica Minolta, Tokyo, Japan). The SPAD readings were taken from five randomly selected leaves of maize and cowpea plants in every plot. These readings were taken from leaf blades, and the average SPAD reading was recorded from each plot.

2.3.2. Determining Thermal Requirements for Flowering

The flowering dates were recorded, and daily maximum and minimum temperatures were collected from a local weather station. The thermal unit was calculated using growing degree days (GDD) using a base temperature of 10 °C [32].

$$\text{GDD} = \sum_{\text{i}}^{\text{j}} \left(\frac{\text{T max} + \text{T min}}{2} \right) - \text{T base}$$

where

i = Sowing date
j = Flowering date
T max = Maximum day temperature (°C)
T min = Minimum day temperature (°C)
T base = Base temperature (°C), which is considered as 10

The rate of development was calculated using the following formula:

$$\text{Average heat unit received per day} = \frac{\text{GDD}}{\text{Days to flowering}}$$

2.3.3. Determining Canopy Coverage and Architecture

Canopy coverage and architecture were determined by capturing and analyzing photographs based on the work of Sakamoto et al. [33]. The digital photograph was captured at a fixed height of 1.75 m using a Nikon D3300 camera during the flowering stage (i.e., at 85 DAS). The area shown in the picture was adjusted to the size of 1 m^2 (1 m × 1 m) within each treatment block. The ISO, aperture (F-stop), and shutter speed data were recorded. The digital number of image pixels for the red, green, and blue image layers (RGB) was obtained using software called GIMP. Then, the digital number was averaged to convert to the calibrated digital number (cDNA). The camera-derived vegetation indices (VIs), i.e., visible atmospherically resistant index (VARI) and two-green-red-blue (2 g-r-b) were calculated using the following formula by Sakamoto et al. [33]. The equations for digital camera-based VIs are as follows:

$$\begin{gathered}\text{VARI (camera)} = \text{cDN}_{\text{green}} - \text{cDN}_{\text{red}}/\text{cDN}_{\text{green}} + \text{cDN}_{\text{red}} \\ \text{2 g-red-b (camera)} = 2 \times \text{cDN}_{\text{green}} - \text{cDN}_{\text{red}} - \text{cDN}_{\text{blue}}\end{gathered} \quad (1)$$

where

$$cDN_{green} = \text{Daytime green pixel}$$
$$cDN_{red} = \text{Daytime red pixel}$$
$$cDN_{blue} = \text{Daytime blue pixel}$$

2.3.4. Yield and Yield Contributing Parameters

At harvesting time, one square meter area was harvested from the middle of each plot to determine biomass production and seed/grain yield. Grains/seeds and maize stovers were cleaned and dried at 60 °C in an oven for approximately 72 h until they reached constant weight. The grain yield of maize and cowpea was recorded and converted to yield per hectare. The harvest index was calculated by the ratio between grain yield and total yield (biomass and grain). Yield-contributing characteristics were determined by obtaining data from five randomly selected maize and cowpea plants from each plot. The plant height, number of plants, number of cobs, number of grains per cob, lengths and diameters of cobs, weights of cobs, and total biomass were recorded for the maize crop. Yield components, such as 1000-grain weight, were also measured. After harvesting cowpea, yield attributes, such as the number of branches and pods per plant, the number of seeds per pod, 1000-seed weight, total biomass, as well as seed yield were measured after drying. The drying was performed at 60 °C in an oven for approximately 72 h until they reached constant weight.

2.3.5. Analysis of Intercropping Systems

The relative yield of intercropping was calculated using the following equation:

$$\text{Relative yield} = \frac{\text{Yield of component crop}}{\text{Yield of sole crop}} \quad (2)$$

The individual crop yield was converted into equivalent yield by equating the prices of the individual crops [34]. Market prices are presented in Table 1. Maize equivalent yield is calculated as:

$$\text{Maize equivalent yield} = \text{Ym} + \frac{\text{Yi} \times \text{Pi}}{\text{Pm}} \quad (3)$$

where

Ym = Yield of maize (kg ha^{-1})
Yi = Yield of intercrop (kg ha^{-1})
Pi = Price of intercrop (Tk. ha^{-1})
Pm = Price of maize (Tk. ha^{-1})

Table 1. Cost of production for different operations and product prices. The price was taken from the local market at Patuakhali on 15 November 2019.

Items	Cost of Production (USD ha^{-1})		
	Maize	**Cowpea**	**Intercropping**
Human Labor	141.18	129.41	176.47
Mechanical Cost	105.88	47.06	105.88
Seed (Purchased)	35.29	5.88	41.18
Urea	19.76	3.29	19.76
TSP (Triple Superphosphate)	14.12	9.41	14.12
MOP (Muriate of Potash)	10.35	5.18	10.35
Insecticide	12.94	11.76	14.12
Irrigation	58.82	23.53	58.82
Machine Cost	16.47	14.12	21.18
Land-Use Cost	117.65	117.65	117.65
Interest on Operational Cost	26.62	18.36	28.98
Total variable cost of cultivation	559.09	385.66	608.51

Harwood [35] defined land equivalent ratio (LER) as the area needed under sole cropping to generate as much produce as 1 ha of intercropping or mixed cropping at the same management level expressed as a ratio. Willey [36] calculated the following formula for LER:

$$\text{LER} = \frac{\text{Yml}}{\text{Ym}} + \frac{\text{Ylm}}{\text{Yl}} \quad (4)$$

where

Yml = yield of maize when intercropped with cowpea
Ym = yield of sole maize
Ylm = yield of cowpea when intercropped with maize
Yl = yield of sole cowpea

Costs and returns were analyzed for the economic assessment of the cropping systems. The gross return was calculated by yield and local market price. The local currency was converted to the United States Dollar with a fixed rate of USD 1 = BDT 85. The benefit-cost ratios (BCR) of different treatments were calculated as follows:

$$\text{BCR} = \frac{\text{Gross return } \left(\frac{\text{tk}}{\text{ha}}\right)}{\text{Variable cost of cultivation } \left(\frac{\text{tk}}{\text{ha}}\right)} \quad (5)$$

The variable cost refers to expenses during the production's field activity and varies depending on the treatments. All cost information is listed in Table 1.

2.3.6. Statistical Analysis

The results were analyzed following a mixed model analysis using treatments as fixed factors and blocks (i.e., replication) as random factor using JPM with analysis of JMP 8 (SAS, USA) software. Tukey's honesty significant test (HSD) was used as a post-hoc test to determine pairwise differences between treatments at a significance level of $p \leq 0.05$. Graphs were prepared using the SigmaPlot V14.0 (Systat Software Inc., London, UK). Detailed information about the statistical result is shown in the Supplementary Materials in this study.

3. Results

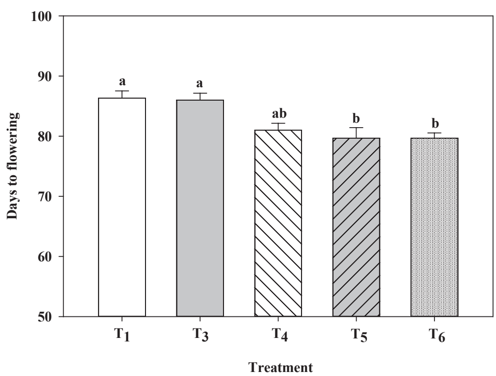
3.1. Effects of Intercropping Systems on Maize Growth

There were no significant effects of intercropping on maize growth in relation to variation in maize height or the number of cobs per plant among the treatments (*F* ratio = 0.55, $p > 0.05$, Table 2 and Table S9). Cob length and diameter differed significantly in maize sown under sole compared to intercropped plants. (*F* ratio = 36.17 and 12.64 for cob length and diameter respectively, $p < 0.01$, Table 2 and Table S5). T_1 had the longest cob (21.3 $\pm$ 0.50 cm) and the highest cob diameter (14.76 $\pm$ 0.23 cm), whereas the shortest cob (17.8 $\pm$ 0.03 cm) and diameter (13.03 $\pm$ 0.08 cm) were in T_6. The number of grains per cob differed significantly among the treatments (*F* ratio = 5.93, $p < 0.01$, Table 2). T_1 (sole maize) produced the highest number of grains per cob (598 $\pm$ 9) and was statistically similar to T_3 (553 $\pm$ 10). On the other hand, all the intercropping treatments, i.e., T_3 to T_6, produced a relatively lower number of grains per cob. A similar trend was also observed in the stover yield, which had the highest statistical values in T_1 followed by T_3, whereas T_6 showed the lowest values (Table 2). No significant difference was observed in the 1000-grain weight and harvest index of maize (*F* ratio = 4.86 and 1.2, respectively, and $p > 0.05$). The successive sowing of maize under intercropping resulted in a significantly lower yield than sole cropping (6.69 $\pm$ 0.26 t ha^{-1}) with the lowest value (4.97 $\pm$ 0.03 t ha^{-1}) in T_6 (Table 5). The cumulative time requirement (day) for flowering was significantly lower in T_5 and T_6 than in other treatments (Figure 1A). At the same time, the average heat units received per day during the vegetative phase of maize was significantly greater in T_6 than in T_1 and T_3 (*F* ratio = 8.2 and 68.79, respectively, $p < 0.01$, Figure 1B).

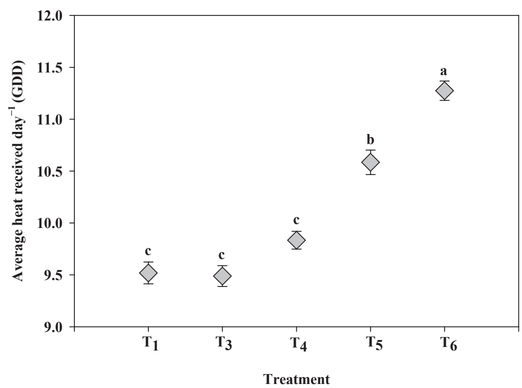
Table 2. Yield and yield contributing characters of maize grown under different treatments (means ± SE, N = 3).

Treatment	Plant Height (cm)	Number of Cobs Plant^{-1}	Cob Characters		Number of Grains Cob^{-1}	1000-Grain Weight (g)	Stover Yield (t ha^{-1})
			Length (cm)	Circumference (cm)			
T_1	237 ± 0.6	1.06 ± 0.06	21.3 ± 0.50 a	14.76 ± 0.23 a	598 ± 9 a	239 ± 3.4	8.61 ± 0.15 a
T_3	235 ± 0.7	1.06 ± 0.06	18.9 ± 0.14 b	14.03 ± 0.12 ab	553 ± 10 ab	238 ± 0.2	8.03 ± 0.09 b
T_4	235 ± 0.5	1	18.4 ± 0.06 bc	13.60 ± 0.20 b	533 ± 9 ab	234 ± 0.6	7.76 ± 0.01 bc
T_5	236 ± 0.6	1	18.1 ± 0.05 bc	13.46 ± 0.40 bc	518 ± 26 b	232 ± 0.4	7.60 ± 0.04 c
T_6	236 ± 0.9	1	17.8 ± 0.03 c	13.03 ± 0.08 c	491 ± 11 b	232 ± 0.2	7.18 ± 0.19 d
F ratio	0.69	0.66	36.17	12.64	5.93	4.86	42.90
p value	0.61	0.63	<0.01	<0.01	<0.01	0.06	<0.01

T_1—sole maize; T_3—maize + cowpea intercropping, simultaneous sowing; T_4—maize + cowpea intercropping, maize sown after 1 wk; T_5—maize + cowpea intercropping, maize sown after 2 wk; and T_6—maize + cowpea intercropping, maize sown after 3 wk.



(**A**)



(**B**)

Figure 1. Days to flowering (panel (**A**)) and average thermal units (growing degree days) per day received during vegetative stage of maize (panel (**B**)) grown under the different sole and intercropping treatments. The treatments are: T_1—sole maize; T_3—maize + cowpea intercropping, simultaneous sowing; T_4—maize + cowpea intercropping, maize sown after 1 wk; T_5—maize + cowpea intercropping, maize sown after 2 wks; and T_6—maize + cowpea intercropping, maize sown after 3 wks. Different letters above the bars indicate statistically significant differences at Tukey's HSD (a = 5%). Error bars represent the standard error of means, N = 3.

In the SPAD, measurements of maize varied significantly for different treatments (*F* ratio = 133.05, $p < 0.01$, Figure 2A). The highest SPAD value was in sole maize (T_1) and it reduced significantly when grown with cowpea. Among the intercropping treatments, SPAD values were lower when maize was sown after cowpea (T_4 to T_6) than the simultaneous maize–cowpea intercropping (T_3). There was also a significant positive relationship between SPAD value and grain yield of maize in Figure 3A ($r^2 = 0.60$, $p < 0.01$).

3.2. *Effects of Intercropping Systems on Cowpea Growth*

The effects of different treatments on cowpea growth are shown in Table 3. There were significant differences between treatments in the number of pods per plant, pod weight, seeds per plant, 1000-seeds weight, stover, and seed yield ($p < 0.05$, Tables S6 and S10). The performance of cowpea in terms of seed and stover yield was significantly greater under sole cropping than intercropping while among the intercropping treatments, T_6 performed better than T_3. However, the performance of T_6 was similar to T_2 regarding the number of pods per plant and number of seeds per plant ($p < 0.05$, Table 3).

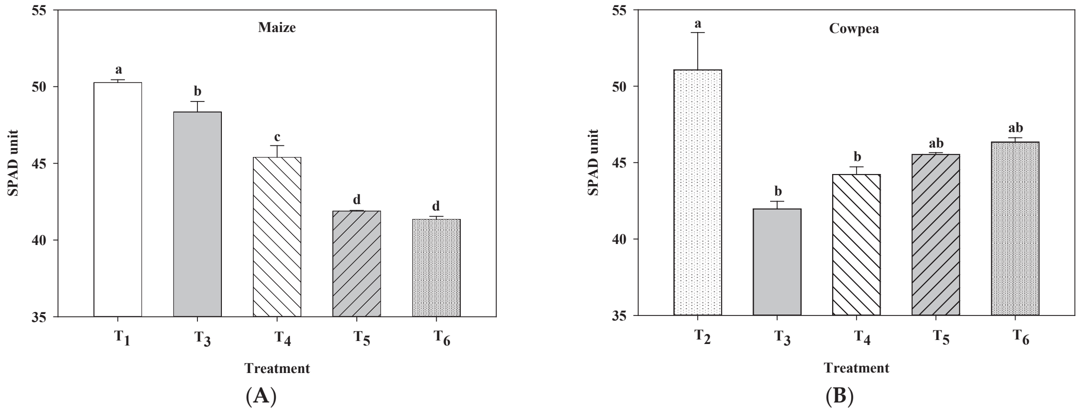


Figure 2. Chlorophyll content measured as soil and plant analysis development (SPAD) values in maize (panel (**A**)) and cowpea (panel (**B**)) leaves. For treatment abbreviations, see Figure 1. Different letters above the bars indicate statistically significant differences at Tukey's HSD (a = 5%). Error bars represent the standard error of means, N = 3.

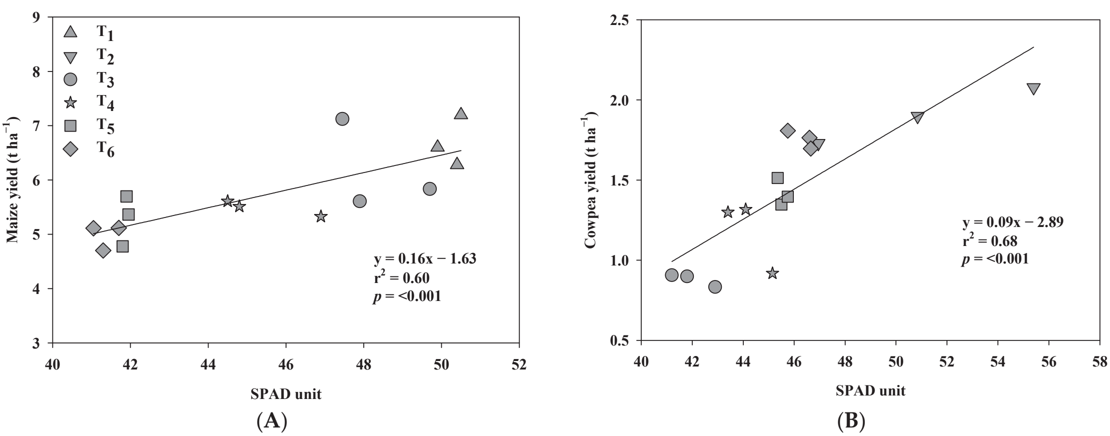


Figure 3. Relationship between soil and plant analysis development (SPAD) value and seed yield of maize (panel (**A**)) and cowpea (panel (**B**)).

No significant difference in plant height, number of branches, number of seeds per pod, nor pod length were found among the treatments ($p > 0.05$, Table 3). The HI was significantly lower in T_3 than all other treatments. Regarding the SPAD measurements of cowpea (Figure 2B), there were significant differences between treatments (F ratio = 7.14, $p < 0.01$, Table S6). Compared to sole cropping (T_2), SPAD values were lower in T_3 and T_4 treatment, while these values were similar in T_5 and T_6 (Figure 2B). Moreover, a positive relationship between SPAD value and cowpea seed yield ($r^2 = 0.68$, $p < 0.01$) is shown in Figure 3B. The values were higher in the sole cowpea treatment (T_2) than intercropping treatments.

Table 3. Yield and yield-contributing characters of cowpea grown under different intercropping practices (means ± SE, N = 3).

Treatment	Plant Height (cm)	Branch Plant^{-1}	Pod Plant^{-1}	Seed Pod^{-1}	Average Pod Length (cm)	Pod Weight per Meter Square Plot (g)	Seed Plant^{-1}	Stover Yield (t ha^{-1})	1000-Grain Weight (g)
T_2	136 ± 15	6.93 ± 0.40	14.4 ± 0.11 a	15.26 ± 0.59	17.84 ± 0.91	290 ± 5 a	220 ± 9 a	2.39 ± 0.03 a	127 ± 1.44 a
T_3	177 ± 31	6.93 ± 1.17	9.2 ± 0.46 c	12.93 ± 0.29	16.64 ± 0.16	211 ± 3 d	119 ± 3 c	1.24 ± 0.06 c	107 ± 0.86 b
T_4	185 ± 8	6.73 ± 0.67	10.2 ± 0.61 c	14.13 ± 0.78	16.71 ± 0.29	222 ± 2 cd	145 ± 16 bc	1.43 ± 0.02 bc	117 ± 0.38 c
T_5	156 ± 37	7.33 ± 0.99	11.83 ± 0.40 b	14.73 ± 0.29	16.74 ± 0.29	237 ± 2 bc	174 ± 6 b	1.53 ± 0.03 b	117 ± 0.44 c
T_6	162 ± 10	9.13 ± 0.69	13.9 ± 0.20 a	15.00 ± 0.11	16.98 ± 0.14	250 ± 2 b	209 ± 5 a	1.66 ± 0.07 b	121 ± 0.51 b
F ratio	0.79	1.43	96.89	3.42	1.09	69.17	47.71	123.81	90.34
p value	0.56	0.31	<0.01	0.06	0.42	<0.01	<0.01	<0.01	<0.01

T_2—sole cowpea; T_3—maize + cowpea intercropping; simultaneous sowing; T_4—maize + cowpea intercropping, maize sown after 1 wk; T_5—maize + cowpea intercropping, maize sown after 2 wks; and T_6—maize + cowpea intercropping, maize sown after 3 wks.

3.3. Intercropping Effects on the Above-Ground Competition

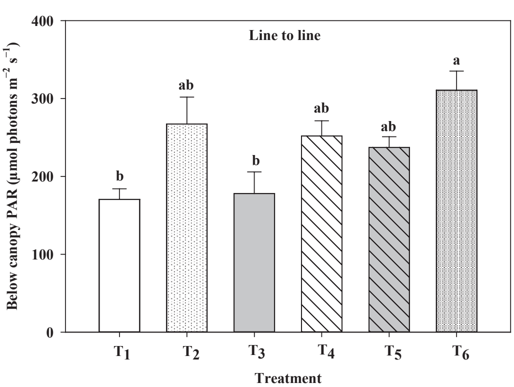
The camara-based vegetative indices, an index for canopy architecture, was measured as 2g-red-b and VARI. There is no significant variation among treatments (F ratio = 0.66, $p > 0.05$, Table 4). Similarly, for VARI, there is no significant variation among treatments (F ratio = 1.45, $p > 0.05$).

Table 4. Canopy coverage and architecture analysis using camara-based vegetative indices (2g-red-b and VARI) for different treatments (Mean ± SE).

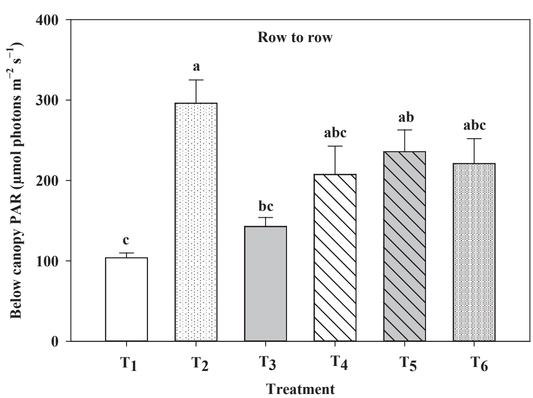
Treatment	2 g-red-b	VARI
T_1	0.416 ± 0.039	0.230 ± 0.0243
T_2	0.463 ± 0.017	0.311 ± 0.0269
T_3	0.426 ± 0.004	0.207 ± 0.0396
T_4	0.437 ± 0.025	0.224 ± 0.0314
T_5	0.446 ± 0.028	0.268 ± 0.0204
T_6	0.408 ± 0.021	0.269 ± 0.0855
F ratio	0.66	1.45
p value	0.65	0.28

T_1—sole maize; T_2—sole cowpea; T_3—maize + cowpea intercropping—simultaneous sowing; T_4—maize + cowpea intercropping, maize sown after 1 wk; T_5—maize + cowpea intercropping, maize sown after 2 wks; and T_6—maize + cowpea intercropping, maize sown after 3 wks.

The below-canopy PAR values measured in between lines and rows showed significant variation among the treatments (F ratio = 4.66 and 6.76, $p < 0.05$, Figure 4A,B, Table S7). The PAR values were relatively lower at T_1 and T_3 than other treatments. There were positive relationships between below-canopy PAR and 2g-red-b ($r^2 = 0.34$ and $r^2 = 0.16$, line to line and row to row, respectively). However, these relationships were not statistically significant (Figure 5).

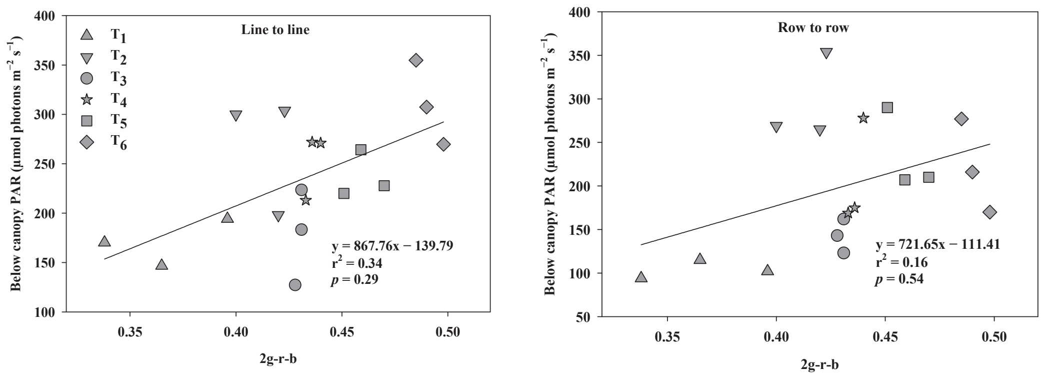


(**A**)



(**B**)

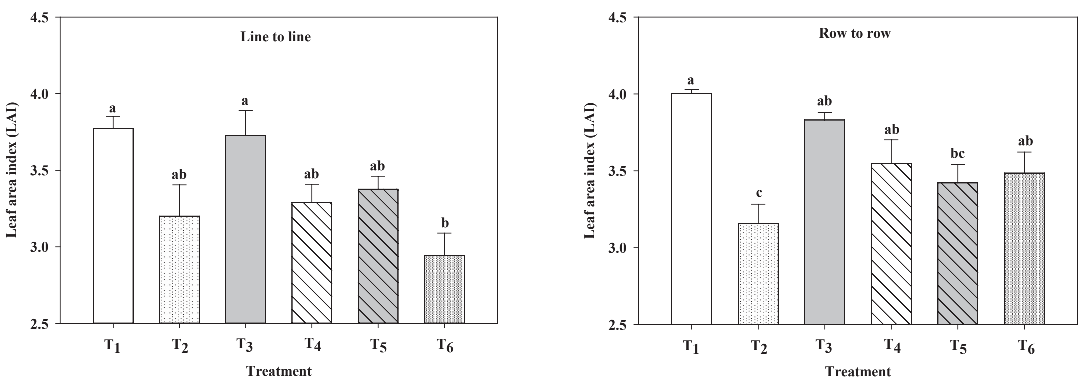
Figure 4. Photosynthetically active radiation (PAR) under the canopy of different sole and intercropping treatments. For treatment abbreviations, see Figure 1. PAR was measured between lines (panel (**A**)) and between rows (panel (**B**)) since canopy coverage was different due to spacing (e.g., the line to line = 60 cm and plant to plant = 20 cm for maize) of the crops. Different letters above the bars indicate statistically significant differences at Tukey's HSD (a = 5%). The error bars represent the standard error of means, N = 3.



(**A**) (**B**)

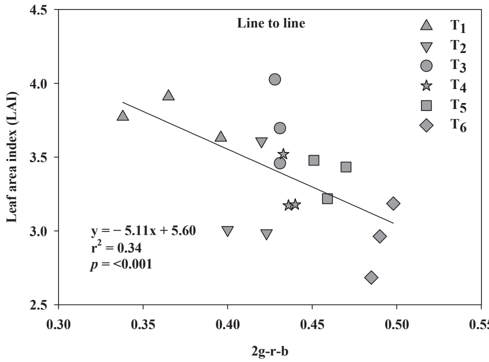
Figure 5. Relationship between below-canopy PAR and 2 g-r-b, line to line (panel (**A**)) and row to row (panel (**B**)). The PAR was measured between lines (panel A) and between rows (panel (**B**)) since canopy coverage was different due to spacing (line to line = 60 cm and plant to plant = 20 cm for maize).

Contrary to PAR, the LAI measured between lines and rows varies depending on treatment (Figure 6). The LAI, measured in between lines, was relatively lower in T_3 than other treatments (*F* ratio = 4.66, $p < 0.01$, Table S7). However, the LAI, measured in between rows, was significantly lower in sole cowpea than all other treatments (*F* ratio = 6.76, $p < 0.01$, Table S7). There were significant negative relationships ($r^2 = 0.34$ and 0.16, respectively for line to line and row to row) between LAI and 2g-red-b (Figure 7).

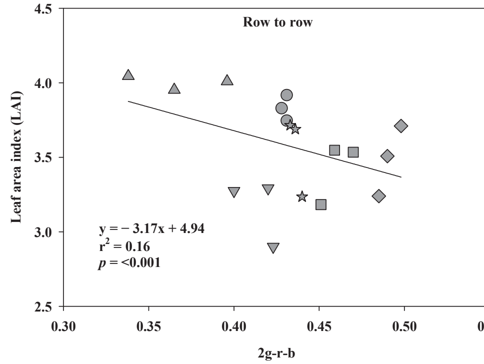


(**A**) (**B**)

Figure 6. Leaf area index (LAI) of different sole and intercropping treatments. For treatment abbreviations, see Figure 1. The PAR was measured between lines (panel (**A**)) and between rows (panel (**B**)) since canopy coverage was different due to spacing (line to line = 60 cm and plant to plant = 20 cm for maize) of the crops. Different letters above the bars indicate statistically significant differences at Tukey's HSD (a = 5%). The error bars represent the standard error of means, N = 3.



(**A**)



(**B**)

Figure 7. Relationship between 2 g-r-b and LAI, measured between the lines (panel (**A**)) and between rows (panel (**B**)). The PAR was measured by taking reading in between lines (panel (**A**)) and in between rows (panel (**B**)) since canopy coverage was different due to spacing (line to line = 60 cm and plant to plant = 20 cm for maize) of the crops.

3.4. Performance of Intercropping

Compared to sole cropping of cowpea, all the intercropped treatments and sole maize cultivation showed a better performance in terms of maize equivalent yield (Table 5 and Table S11). The highest maize equivalent yield was recorded in T_3 (6.72 $\pm$ 0.46 t ha^{-1}), and the lowest maize equivalent ratio was found in T_1 (1.14 $\pm$ 0.06 t ha^{-1}). However, the performance of maize under sole and intercropping were similar in terms of maize equivalent yield. The LER was significantly greater in the intercropping system than in both sole cropping practices (*F* ratio = 35.26, $p < 0.01$, Table 5). Moreover, among intercropping practices, it was significantly greater in $T_{6,}$ LER (1.67 $\pm$ 0.05) than other treatments (e.g., LER (1.39 $\pm$ 0.09) at T_3).

3.5. Economic Profitability

The economic performances, calculated as total gross and net return and BCR, varied significantly (*F* ratio = 44.33, 23.04, and 14.34, respectively and $p < 0.01$, Table 6). Specifically, the total gross return was significantly greater in intercropping practices (e.g., USD 1394.82 $\pm$ 25.08 ha^{-1} in treatment T_6), than sole cowpea (USD 559.62 $\pm$ 29.57 ha^{-1}). Similar to gross return, there was a relatively greaterer net return (e.g., USD 786.32 $\pm$ 25.08 ha^{-1} in T_6) than T_2 (USD 173.97 $\pm$ 29.57 ha^{-1}). As a result, the BCR was greater in intercropping treatments (e.g., 2.29 $\pm$ 0.04 in T_6) than T_2 (1.45 $\pm$ 0.08). However, the performance of sole maize was similar to intercropping in terms of total gross and net returns and thus benefit cost ratios.

Table 5. Yield performance of maize-cowpea grown (means ± SE, N = 3) under different practices.

Treatment	Seed Yield (t ha^{-1})		Biological Yield (t ha^{-1})		Harvest Index		Maize Equivalent Yield (t ha^{-1})	LER
	Maize	Cowpea	Maize	Cowpea	Maize	Cowpea		
T_1	6.69 ± 0.26 a	—	15.30 ± 0.41 a	—	0.43 ± 0.01	—	6.69 ± 0.27 a	1 c
T_2	—	1.9 ± 0.10 a	—	4.29 ± 0.13 a	—	0.44 ± 0.77 ab	1.14 ± 0.06 b	1 c
T_3	6.18 ± 0.47 ab	0.87 ± 0.02 c	14.21 ± 0.56 ab	2.11 ± 0.08 d	0.43 ± 0.02	0.41 ± 0.27 b	6.72 ± 0.46 a	1.39 ± 0.09 b
T_4	5.48 ± 0.08 ab	1.17 ± 0.13 b	13.24 ± 0.09 bc	2.60 ± 0.15 c	0.41 ± 0.00	0.45 ± 0.86 ab	6.19 ± 0.06 a	1.43 ± 0.06 b
T_5	5.27 ± 0.26 b	1.41 ± 0.04 b	12.87 ± 0.30 bc	2.94 ± 0.07 bc	0.40 ± 0.01	0.48 ± 0.62 ab	6.13 ± 0.27 a	1.54 ± 0.04 ab
T_6	4.97 ± 0.13 b	1. 75 ± 0.03 a	12.15 ± 0.32 c	3.41 ± 0.54 b	0.40 ± 0.01	0.52 ± 0.31 a	6.03 ± 0.14 a	1.67 ± 0.05 a
F ratio	5.51	53.87	14.29	172.27	1.26	5.38	65.07	35.26
p value	<0.01	<0.01	<0.01	<0.01	0.35	0.02	<0.01	<0.01

T_1—sole maize; T_2—sole cowpea; T_3—maize + cowpea intercropping, simultaneous sowing, T_4—maize + cowpea intercropping, maize sown after 1 wk; T_5—maize + cowpea intercropping, maize sown after 2 wks; and T_6–maize + cowpea intercropping, maize sown after 3 wks.

Table 6. Economic returns from maize-cowpea intercropping systems.

Treatment	Gross Return (USD ha^{-1})			Total Variable Cost (USD ha^{-1})	Net Return (USD ha^{-1})	BCR
	Maize	Cowpea	Total			
T_1	1180.94 ± 47.50 a	—	1180.94 ± 47.50 a	559.09	621.84 ± 47.50 a	2.11 ± 0.08 a
T_2	—	559.62 ± 29.57 a	559.62 ± 29.57 b	385.66	173.97 ± 29.57 b	1.45 ± 0.08 b
T_3	1092.17 ± 83.35 ab	258.58 ± 6.85 c	1350.75 ± 76.69 a	608.51	742.24 ± 76.69 a	2.22 ± 0.13 a
T_4	967.58 ± 14.57 ab	346.46 ± 38.27 b	1314.05 ± 29.17 a	608.51	705.54 ± 29.17 a	2.16 ± 0.05 a
T_5	931.63 ± 47.46 b	417.34 ± 14.50 b	1348.97 ± 47.69 a	608.51	740.47 ± 47.69 a	2.22 ± 0.08 a
T_6	878.16 ± 24.22 b	516.66 ± 9.53 a	1394.82 ± 25.08 a	608.51	786.32 ± 25.08 a	2.29 ± 0.04 a
F ratio	80.58	150.08	44.33		23.04	14.34
p value	<0.01	<0.01	<0.01		<0.01	<0.01

T_1—sole maize; T_2—sole cowpea; T_3—maize + cowpea intercropping, simultaneous sowing; T_4—maize + cowpea intercropping, maize sown after 1 wk; T_5—maize + cowpea intercropping, maize sown after 2 wks; and T_6- maize + cowpea intercropping, maize sown after 3 wks.

4. Discussion

4.1. Maize Productivity

Crop performance can be affected when grown under different levels of competition [28]. In our experiment, maize produced significantly greater biomass and grain yield in sole cropping than intercropped with cowpea. The largest reduction in maize yield (25.7%) was observed in maize–cowpea intercropping, where maize was sown 3 wks after cowpea. This reduction in yield could be associated with competition between species for resources. When crops are sown consecutively, the first crop generally receives a competitive advantage over the other [37–39]. We observed a similar phenomenon in our study. Maize likely had less access to some of the resources (e.g., nutrient and water) when it was sown after cowpea [37]. For instance, the SPAD value, an indicator for plant nitrogen content, was significantly lower in T_6 t than the other treatments, while a significant positive relationship was obtained between SPAD value and grain yield of maize (Figure 3). In contrast, the competition for light resources might not have played a significant role in reducing the yield of maize when sown after cowpea as the below-canopy PAR was higher in T_6 compared to T_1 (sole cropping) and T_3 (simultaneous sowing). The late-sown maize completed its vegetative period faster than sole and simultaneous intercropping due to experiencing a relatively higher average temperature during the vegetative period. This suggests that this treatment had less opportunity to accumulate sufficient assimilate to partition into grain (Figure 4). These results suggest that maize yield was sacrificed due to late planting, which may be related to competition for soil nutrients and changes in climate conditions.

4.2. Cowpea Productivity

Cowpea, being a legume, is less competitive than maize since maize is generally taller with a fast-growing or more extensive root system [40,41]. Therefore, it is likely that intercropping of these species may reduce the yielding ability of cowpea to a greater extent than maize. In our study, cowpea yielded the maximum when cultivated as a sole crop, whereas the lowest yield was observed when maize and cowpea were sown simultaneously (Table 6). Among the intercropped treatments, its seed yield increased with the increasing time-lapse of maize sowing. The maximum seed yield was achieved from T_6 (i.e., sowing maize after three wks), a yield comparable to the sole cropping (Table 6). However, the biological yield of T_2 (sole cowpea) was significantly greater than T_6. Compared to sole cropping, the reduction in yield in intercropping practices can be attributed to the competition for different resources (light, nutrient, and possibly water). However, these competitions for resources were lessened when maize was sown after cowpea, especially in T_6. Because cowpea was grown alone in the first three weeks, leading to an increase in its competitive ability, the difference in sowing time changed the resource demand. The study's results support these attributions. For instance, the chlorophyll content measured in cowpea leaves was significantly lower in cowpea grown simultaneously with maize, whereas these values increased when maize was sown after cowpea. Moreover, the share of cowpea biomass to the combined biological yield increased from 12% in the simultaneous sowing of both species to 22% in the T_6 (Table 6). Altogether, our results confirm previous findings where TND were examined as a mean of increasing intercropping productivity [27].

Fertilizer application at different rates can affect crop yield. The amount of N application in our study was different for sole (20 kg ha^{-1}) and intercropping since, in intercropping (120 kg ha^{-1}), both maize and cowpea share the applied N. Although the amount of N input was different between T_2 and T_6, no significant difference was observed in seed plant^{-1} (Table 3) and seed yield (Table 5) of cowpea. This result suggests that maize possibly absorbed most of the applied N, since it cannot fix N, while it has larger root volume, providing an advantage to acquire N [42,43]. In fact, legumes preferably fix more N when grown with other species [44]. However, N fixation may reduce yield since it is an energy-driven process.

4.3. Intercropping Performance

Intercropping using TND can significantly reduce competition between species since the resource demand of one space does not completely overlap with their component species. This allows for diversity in resource uses both in time and space [16,38,42]. However, there are trade-offs between complementarity and competition interactions among different species shaping the outcome of any intercropping practices. In our study, the yield performance of maize was reduced by 7.5% and 25%, respectively, in T_3 (simultaneous) and T_6 (TND for 3 wks) when compared to sole cropping (Figure S4). The possible reasons are a reduction in resource availability and changes in climatic conditions (discussed in the previous section). As expected, the seed yield of cowpea was higher in the T_6 and relatively lower in T_3 due to getting an advantage of resources use (light, water, and nutrient) (Figure S5). The combined outcome of the intercropping systems is usually evaluated with LER and equivalent yield performance (here, maize equivalent yield). The cumulative relative performance (i.e., LER) was significantly higher in T_6 than $T_{3,}$ suggesting that there is an overall benefit of intercropping with a 3-wk sowing delay rather than simultaneous intercropping. However, the maize equivalent yield of each intercropping system was similar, and not different from sole maize. Moreover, the maize and cowpea combined biomass production was slightly greater in T_3 than T_6. The economic returns of all intercropped treatments were also similar to sole maize. All these results suggest that intercropping practices were not beneficial over sole cropping of maize, while intercropping with TND was also not advantageous. However, maize cowpea intercropping was more beneficial than sole cowpea in all aspects (LER, maize equivalent yield, and economic benefits), suggesting species specific advantages of intercropping. These discrepancies also underscore the relative economic value of a crop. Since the price of cowpea is relatively low, the yield advantages achieved through cowpea did not have enough weightage to have a significant effect among different intercropping treatments.

Interactions of component species in terms of resources and their feedback determine the overall performance of intercropping. In our case, there were competitions for resources under intercropping practices that caused a reduction in yield, contrary than their sole cropping counterparts. For instance, N concentration in leaves of both species, determined using a SPAD meter, was lower under intercropping than sole cropping. In addition, there was a significant positive relationship between SPAD value and yield for maize and cowpea. These results indicate that competition for N determines the yield of component crops. Among the intercropping practices, an increase in sowing time difference increases the SPAD value of cowpea while it was reduced in maize. Although biological nitrogen fixation (BNF, measured as the number of nodules) (Figure S3) and N concentration (as SPAD value) was higher in T_6 than T_3 in cowpea, this greater N supply did not change the overall performance of both species. In contrast to our findings, previous studies reported that increased BNF could increase the yields in maize–legume intercropping systems [10,43]. Although it is expected that N acquisition from different soil layers and N transfer from legume to non-legume component species could contribute to greater N acquisition than sole cropping, N supply through these processes might be minimal in our case [23,25,43,44]. Although not measured in this study, intercropping could have increased the nutrient stock in the soil by reducing nutrient loss and thus, could improve their uptake (e.g., P and K) due to the complementarity interactions between species [45–48]. Apart from complementary nutrients, TND (sequential planting) also improved plant moisture acquisition since established cowpea experienced less sensitivity to moisture stress [49,50].

5. Conclusions

We assessed the performance of maize–cowpea intercropping when maize was sown after the planting of cowpea. In our experiment, both maize and cowpea production were reduced under intercropping than in sole cropping. When the performance of intercropping was assessed in terms of LER and maize equivalent yield, intercropping was advantageous in terms of land utilization but not in terms of maize equivalent yield. Moreover, the performance of maize regarding the maize equivalent yield was similar under sole and intercropping. However, the relative advantage of intercropping, in terms of LER, and net returns was greater than sole cowpea. These discrepancies in performances suggest that a relatively low monetary contribution of the component crop may not provide a greater economic benefit, although there is a clear advantage of land utilization. Considering all these together, it can be concluded that maize–cowpea intercropping with maize sown 3 wks after cowpea was advantageous in terms of land utilization for farmers in Bangladesh. Future studies are needed to explore and assess this approach covering efficiency use of water and nutrients in different seasons and contrasting environments over several years.

Supplementary Materials: The following supporting information can be downloaded at: https://www.mdpi.com/article/10.3390/land11040581/s1, Figure S1: Schematic diagram of experimental design; Figure S2: A photograph of field trial; Table S1: Monthly average air temperature, humidity and total rainfall, cloud and sunshine of the experimental site during the period from December 2018 to May 2019; Table S2: Sowing dates and duration between maize and cowpea; Table S3: General morphological indicators and the growth habit of cowpea; Table S4: Age of cowpea and maize in measurement of LAI, light interception, Canopy coverage and architecture; Table S5: ANOVA of yield and yield contributing characters of maize; Table S6: ANOVA of yield and yield contributing characters of cowpea; Table S7: ANOVA of Intercropping effects on the above-ground competition; Table S8: ANOVA of intercropping systems on the economic analysis; Table S9: REML variance component estimates of maize; Table S10: REML variance component estimates of cowpea; Table S11: REML variance component estimates of intercropping analysis; Table S12: REML variance component estimates of above-ground competition; Figure S3: Nodules plant-1 of cowpea grown under different intercropping practices. The treatments are: T2—sole cowpea, T3—maize + cowpea intercropping, simultaneous sowing, T4—maize + cowpea intercropping, maize sown after 1 wk, T5—maize + cowpea intercropping, maize sown after 2 wk, and T6—maize + cowpea intercropping, maize sown after 3 wk. Different letters above the bars indicate statistically significant differences at Tukey's HSD (a = 5%). Error bars represent the standard error of means, N = 3; Figure S4. Changes in the performance maize due to its cultivation under difference practices; Figure S5. Changes in cowpea yield as influenced by different cultivation practices; Figure S6. Yield advantage and economic benefits of intercropping.

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Article

Calculation of Ecological Compensation Standards for Arable Land Based on the Value Flow of Support Services

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Abstract: Food production is the basis for ensuring human survival. Ecological compensation for arable land is important to ensure the sustainable use of arable land and food production. However, how is it possible to set the standard of ecological compensation and how to achieve it scientifically? In this paper, we take China as the study area and link the ecological compensation of arable land with the production, circulation and consumption of three staple foods. The amount of food is converted into the area of arable land needed to produce that food. After calculating the value of ecosystem services that support food production on arable land, the ecological compensation standard is obtained, and the realization mode between regions is constructed. The results show that: (1) the flow of staple foods in China is mainly from north to south and the value of arable land support services provided by northern provinces is greater than that of southern provinces; (2) the province that needs to pay the most ecological compensation for cultivated land is Guangdong Province, with an amount of ¥16.082 billion RMB, and the province that receives the most compensation is Heilongjiang Province, with an amount of ¥21.547 billion RMB; (3) in order to coordinate the collection and distribution of ecological compensation in each province, it is necessary to establish an ecological compensation fund for arable land in the central government. Protecting the ecological status of arable land and ensuring sustainable food production is in the overall interest of the country.

Keywords: arable land ecological compensation; arable land support services; food production; China

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1. Introduction

Ecosystems not only provide products such as food, medicine and raw materials necessary for human life, but also maintain the life support system that humans rely on for survival and development [1]. The Millennium Ecosystem Assessment (MA) classifies ecosystem services into four categories: provisioning, regulating, supporting and cultural services [2]. Provisioning services are often reflected in economic markets in the form of products, such as food and logs. Regulating services such as climate, water and gas regulation are mostly carried by wind or water flows and are valorized between ecosystem service providers and consumers through horizontal ecological compensation (PES). Cultural services are embodied in the form of attracting tourists [3]. Support services, on the other hand, are missing both in market mechanisms and in the policy framework of PES.

MA defines support services as services that guarantee the virtuous cycle of local ecosystems, such as soil formation, nutrient cycling and biodiversity [2]. Thus, support services are the basis for provisioning, regulating and cultural services [2]. Take the production of grains, vegetables and other foods as an example. Soil formation and maintenance are necessary for food production; nutrient cycling is a source of nutrients in the food growth process, and biodiversity also contributes to the suitability of food production for the environment [4]. In addition to the input of labor and material resources, food production cannot be guaranteed without the support services of arable land. However, under the current market mechanism, the prices of food such as grains and vegetables often only include seeds, fertilizers, pesticides, tools and a small amount of labor costs [5], and do not include the ecosystem service value that supports food production in arable ecosystems. Therefore, behind the flow and consumption of food lies the problem of cross-regional occupation and supply of arable land support services.

Grain is the most important food group. China has a large population and a large demand for grain, while the arable land per capita is small [6]. Under such pressure, higher and higher yield per unit area becomes the only option for food production in China [7]. Thirteen of China's 34 provinces are major grain-producing regions, and accounted for 76% of national production in 2019 [8]. The shift from subsistence smallholder production to modern agriculture pursuing high yields has resulted in increasing inputs of chemical fertilizers and pesticides. Inevitably, food production began to put pressure and damage on arable ecosystems, and even brought more serious problems of surface pollution [9]. Support services have also been severely compromised as a result. The major food-producing provinces have their own urgent economic development needs and agricultural production tasks, as well as the loss of ecosystem services resulting from the high occupation and output of arable land. Therefore, it is necessary to solve the problem of cross-regional occupation and supply of cultivated land support services through administrative means, while protecting the cultivated land ecosystem.

In relatively developed regions and countries, ecocompensation is often referred to as Payment for Ecosystem/Environment Service (PES), and researchers focus more on ecosystem services that can be traded in the market and are useful to humans [10,11], while in developing countries, where socioeconomic development is relatively backward, the overuse of natural resources by population growth and economic growth is the major cause of ecosystem degradation [12]. Ecological compensation is more concerned with regulating the relationship between stakeholders by economic instruments [13]. It is often linked to regional development in order to improve the effectiveness and sustainability of compensation [14,15]. In recent years, many scholars have carried out extensive research on the basic theories [16], systems [17–19], compensation standards [20] and implementation mechanisms of ecological compensation. They have made positive progress in areas such as forests [21,22], grasslands [23,24], wetlands [25,26], watersheds [27,28] and national parks [29]. At present, there are relatively few studies on ecological compensation for cultivated land. While foreign researchers have focused on the policy effects of compensation [30], participation in compensation policies [31] and barriers faced in compensation [32], Chinese researchers have conducted a series of studies around compensation standards. There are two main ideas. One is based on the Contingent Valuation Method (CVM) [33], the other on the ecosystem service value method (ESVM) [34]. Both methods have sound theoretical bases and scientific principles and have been widely recognized by researchers. However, the CVM is based on social surveys, which cannot reflect the compensation mechanism from the perspective of actual supply and consumption of ecosystem services. In the existing ESVM, researchers often consider all four ecosystem services [35], which tends to make the compensation standard higher. For example, the beneficiaries of regulating services are related to the influence range of wind or waterflow, and the value of cultural services is reflected by attracting tourists. The ecological compensation of cultivated land is inseparable from food production. We characterize the cross-regional occupation and supply of cultivated land support services through the production, circulation and consumption of food. Using this as the mechanism of compensation can better solve the problems of compensation subject and object and standard formulation.

Based on this, this paper takes the production, circulation and consumption of three staple food in China as the research object to reveal the cross-regional occupation and supply of arable land support services among provinces, building a bridge between the socio-economic system and the ecological value system. Meanwhile, on the basis of accounting for the value of arable land support services, the ecological compensation standard is obtained. Based on the ecological compensation mechanism, the way to realize the ecological compensation of arable land with the state as the hub and between regions is constructed to protect the cultivated land ecosystem and solve the problem of equitable development between regions.

2. Materials and Methods

2.1. Study Area

The People's Republic of China (China) is located at 73°29′–135°2′ E and 3°31′–53°33′ N. It has a land area of about 9.6 million km^2 and is governed by 23 provinces, five autonomous regions, four municipalities and two special administrative regions (all referred to as provinces). Due to the limitation of data collection, only 31 provinces are covered in this study, excluding Hong Kong, Macao and Taiwan (Figure 1). China's terrain is high in the west and low in the east, with rich and diverse geographic landscapes and climate patterns. China is the most populous country in the world, with about 1.39 billion people. Over the past few decades, through hard struggle, China has achieved a historic transformation from not having enough to eat to having enough to eat and having good food on its own. As of 2019, China has about 119 million hectares of arable land, and the total grain output ranks first in the world.

Figure 1. Location of study areas.

On the other hand, China's food production at this stage is misaligned with the natural production conditions. Since ancient times, the center of food production in China has been in the south, and the flow pattern of staple foods has been southern grain transported to the north [36]. Compared with the northern regions, the southern regions have more sunlight and more abundant water and have the advantage of agricultural production. However, due to the variability of economic development levels and policies, six of the top eight provinces in China's grain production in 2019 are located in the northern region. The flow of staple foods has reversed to northern grain transported to the south [37]. As with other ecosystems, there are carrying capacity boundaries for arable land ecosystems. In the north, where light, heat and water resources are relatively poor, this high yield of food production comes at the cost of excessive depletion of soil fertility and damage to cropland ecosystems [38–40]. It not only inhibits the function of local arable land ecosystem services, but also is detrimental to the sustainable use of arable land and food production.

Therefore, how to construct an effective ecological compensation mechanism for arable land to reduce the damage in the process of food production is important to guarantee both food production and regional equity.

2.2. Methodology

In this study, data on food production and consumption in each province are used to obtain the area of arable land needed to produce the corresponding amount of food. The difference between the area required for production and the area required for consumption is the area of arable land that each province occupies or supplies to other provinces across the region. Then, by calculating the value of arable land support services per unit area, we get the value of ecosystem support services occupied or supplied to other regions by each province, which is also the amount of arable land ecological compensation that each province should pay or receive.

2.2.1. Cross-Regional Occupation and Supply of Cultivated Land Areas

First, since the China Statistical Yearbook contains data on food production, but not on food consumption, we needed to estimate the consumption of food in each province. There are two common macro models. The first model uses data from the China Nutrition Tower and multiplies the daily food intake recommended by experts with the population number to finally obtain the food consumption [41,42]. The drawback of this method is that few people follow the amount of food recommended by the Nutrition Tower. The second model divides food consumption into four categories according to their uses: for eating, for feed, for industry, and for seeds. The four types of food consumption are corrected and estimated by coefficients based on the data available in the statistical yearbook [43,44]. Although the coefficients chosen by the researchers vary, they are generally within a certain range. Thus, this method has a relatively wide application [45,46]. This method was also used in this study.

Second, to convert from food consumption to the area of arable land needed to produce that food, we referred to the ecological footprint model [47]. The ecological footprint was proposed by Wackernagel and Rees [48] and has been developed for more than two decades. It assesses the human impact on ecosystems by measuring the amount of nature that humans use to sustain themselves. For example, assessing a person's food consumption can be converted into the area of arable land needed to produce that food. Animal consumption, on the other hand, can be converted into the amount of feed needed to raise those animals, and then into the area of arable land needed to produce that feed [48–50].

Rice, wheat and maize are the most important types of food produced and consumed in China. Therefore, the compensation standards calculated in this study were obtained based on considering only rice, wheat, and maize. There is a difference in the value of cultivated land support services between dry land and paddy field. Rice is grown in paddy fields and wheat and corn are grown in dryland. Therefore, the annual area of paddy field and dry land to be occupied for food grain, feed grain, industrial grain and seed were calculated separately.

Food grain is the most basic and important way of grain consumption. this paper obtained the food grain consumption of each province in China based on the "per capita consumption of major food items in households by region" in the China Statistical Yearbook. We corrected for consumption using the waste factor and the eating out factor. One study shows that China wastes about 50 billion kg of food per year [51]. According to a study by Xiao [52] in 2002 and referring to China's current level of economic development, we set the factor of eating out at 12% in 2018. For each province, the annual area of dry land required for food grain ($A_{\lambda f}$) is:

$$A_{\lambda f} = \sum_{n=1}^{2} \frac{cpe_n(1 + h + b)}{x_n} \tag{1}$$

The area of paddy fields ($A_{\mu f}$) is:

$$A_{\mu f} = \frac{cpe_{\varepsilon}(1+h+b)}{x_{\varepsilon}} \tag{2}$$

where n = 1 and 2 represent wheat and corn, respectively, $\mathcal{E}$ represents rice, c is the per capita consumption of grains, p is the number of resident population, e is the proportion of consumption of each staple food, h is the proportion of food used for eating out, x represents the grain production per unit area in the province. b is the waste factor, implying the amount of waste corresponding to each kg of food consumed, which can be expressed as:

$$\mathrm{b} = \frac{W}{C} \tag{3}$$

where W is the total annual food waste in China and C is the total annual food consumption in China.

Feed grain, also known as indirect grain consumption, is the total amount of grain consumed for the production of various livestock products converted from grain, such as meat (including pork, beef and mutton, etc.), milk, eggs and aquatic products. In this paper, considering the actual production situation in China and the international and domestic standards, the feed to meat ratio (FCR) for pork is 4.3:1, for poultry is 2.7:1, for eggs are 2.7:1, for beef and mutton is 2:1, for dairy products is 0.3:1, and for aquatic products is 0.4:1. According to the research of Long [53], feed grain in Chinese feed accounts for about 74% [44,49]. The annual area of dry land to be occupied for feed grain in each province ($A_{\lambda \mathrm{c}}$) is:

$$A_{\lambda \mathrm{c}} = \sum_{m=1}^{7} \sum_{n=1}^{2} \frac{y_m \mathrm{r}_m a_n}{x_n} \cdot k \tag{4}$$

The area of paddy fields ($A_{\mu \mathrm{c}}$) is:

$$A_{\mu \mathrm{c}} = \sum_{m=1}^{7} \frac{y_m \mathrm{r}_m a_{\varepsilon}}{x_{\varepsilon}} \cdot k \tag{5}$$

where m = 1, 2...7 represent pork, poultry, beef, mutton, eggs, milk and aquatic products, respectively, y is the annual production, r represents the feed to meat ratio (FCR), which is the amount of feed consumed by the raised livestock to gain 1 kg of weight, a represents the ratio of various grains in the feed and k is the coefficient of grain in the feed, equal to 0.74 [53].

Industrial grain refers to the collective term for grain used in industries that use grain as the main raw material or auxiliary material. Various products such as liquor, alcohol and monosodium glutamate (MSG) are the main products of industrial grain. Therefore, we choose four industrial products, namely liquor, beer, alcohol and MSG, and estimated them according to the corresponding discounted grain coefficients [52]. Through extensive literature research, we used a grain folding factor of 1:2.3 for white wine, 1:0.172 for beer, 1:3 for alcohol and 1:24 for MSG [52]. The theoretical dryland area ($A_{\lambda g}$) to be occupied annually by industrial grain in each province can be expressed as:

$$A_{\lambda g} = \sum_{u=1}^{4} \sum_{n=1}^{2} \frac{y_u \rho_u s_u t_n}{x_n} \tag{6}$$

The area of paddy fields ($A_{\mu g}$) is:

$$A_{\mu g} = \sum_{u=1}^{4} \frac{y_u \rho_u s_u t_{\varepsilon}}{x_{\varepsilon}} \tag{7}$$

where u = 1, 2, 3, 4 represent white wine, beer, alcohol and MSG respectively, ρ represents the average density of the liquid, s is the coefficient of grain folding and t represents the proportion of each crop in the production of industrial products.

Seed grain use accounts for a relatively small amount of about 1% per year. We extrapolated from the amount of grain used per unit area of seed for different food crops and their sown area. Referring to the study of Yao [44], the sowing rates were estimated according to 75 kg/hm^2 for rice, 150 kg/hm^2 for wheat and 75 kg/hm^2 for maize. For a province, the formula for estimating the area of dry land occupied by seed grain ($A_{\lambda \mathrm{s}}$) is:

$$A_{\lambda \mathrm{s}} = \sum_{\mathrm{n}=1}^{2} \frac{d_n \gamma_n}{x_n} \tag{8}$$

The area of paddy fields ($A_{\mu \mathrm{s}}$) is:

$$A_{\mu \mathrm{s}} = \frac{d_\varepsilon \gamma_\varepsilon}{x_\varepsilon} \tag{9}$$

where, d is the sown area of the grain in the region, and γ is the amount of seed sown per unit area of the grain.

We subtracted the area of arable land required for food consumption from the area of food sown (obtained from the statistical yearbook). If the value was positive, it means that the province supplies arable land resources to other provinces and should receive the compensation amount. Otherwise, the province takes arable land area of other provinces in the process of food consumption and should pay the compensation amount. For dry lands, the area supplied or occupied for each province (A_λ) can be expressed as:

$$A_\lambda = A_{\lambda o} - A_{\lambda f} - A_{\lambda c} - A_{\lambda g} - A_{\lambda s} \tag{10}$$

For paddy fields, the area supplied or occupied (A_μ) can be expressed as:

$$A_\mu = d_\varepsilon - A_{\mu f} - A_{\mu c} - A_{\mu g} - A_{\mu s} \tag{11}$$

where $A_{\lambda o}$ denotes the sum of sown area of wheat and corn, $A_{(\lambda,\mu)}$ is positive to represent the supplied area and $A_{(\lambda,\mu)}$ is negative to represent the occupied area.

2.2.2. Assessment of the Value of Arable Land Support Services

In addition to the sale price of food, which reflects the supply services of the arable ecosystem, food also contains the value of arable land support services that support its production. Currently, there are three main methods for valuing ecosystem services per unit area: the Contingent Valuation Method (CVM), the functional value assessment (FVA) and the equivalent factor assessment (EFA).

Because our study area covered 31 provinces in China, it was difficult for us to meet the requirements of the CVM with numerous questionnaire surveys [54]. The FVA, on the other hand, often requires different ecological equations and coefficient inputs for different service functions [55]. The calculation process is more complicated, so this method is mostly focused on small-scale study areas.

The third method is the equivalent factor assessment (EFA). The EFA was first proposed by Costanza [56] in *Nature*. Compared to the FVA, the EFA is more intuitive and easy to use, and is particularly suitable for valuing ecosystem services at large-scales. Based on the Costanza's valuation system, the Chinese scholar Xie conducted a questionnaire survey of about 700 Chinese professionals with ecological background in 2002 and 2007, respectively, and came up with a new and more suitable unit price system for ecosystem valuation in China [57]. Based on this, the EFA was improved and developed in 2015 by combining statistical information and remote sensing monitoring [58]. As of March 2021, this ecosystem service value equivalent system has accumulated more than 6000 citations in China. Therefore, this study used the results of Xie's study to select specific parameters related to support services in arable ecosystems for calculation (Table 1).

Table 1. Supporting service value equivalent of arable ecosystem per unit area.

Arable Ecosystem Classification	Support Services		
Secondary Classification	Soil Conservation	Nutrient Circulation	Biodiversity
Dry Land	1.03	0.12	0.13
Paddy Field	0.01	0.19	0.21

Based on this, the value of ecosystem support services per unit area for arable land (V) can be expressed as:

$$V_{(\lambda,\mu)} = \sum_{i=1}^{3} Q \cdot l_{(i\lambda,i\mu)} \tag{12}$$

where λ and μ represent dry land and paddy field, respectively, i denotes three specific categories of arable land support services, Q is the amount of economic value of one ecosystem service value equivalent factor, which in this paper, refers to the improved research results of Xie 2015, Q takes the value of ¥3406.5 hm^{-2} [58] and l represents the value equivalent factor of the cultivated land support services per unit area.

2.2.3. Calculation of Ecological Compensation Standard for Arable Land

Based on the above calculation, the area supplied or occupied by each province to other provinces is multiplied with the value of ecosystem support services per unit area of cropland to obtain the standard (Y) that each province should compensate or be compensated. It can be expressed as:

$$Y = A_\lambda \times V_\lambda + A_\mu \times V_\mu \tag{13}$$

2.3. Data Source

In order to understand the cross-regional occupation and supply of arable land support services behind the production, circulation and consumption of food in China, this study collected production and consumption data of wheat, corn and rice in 31 provinces. We also obtained the model methods and related parameters on the value of cultivated land support services through literature research.

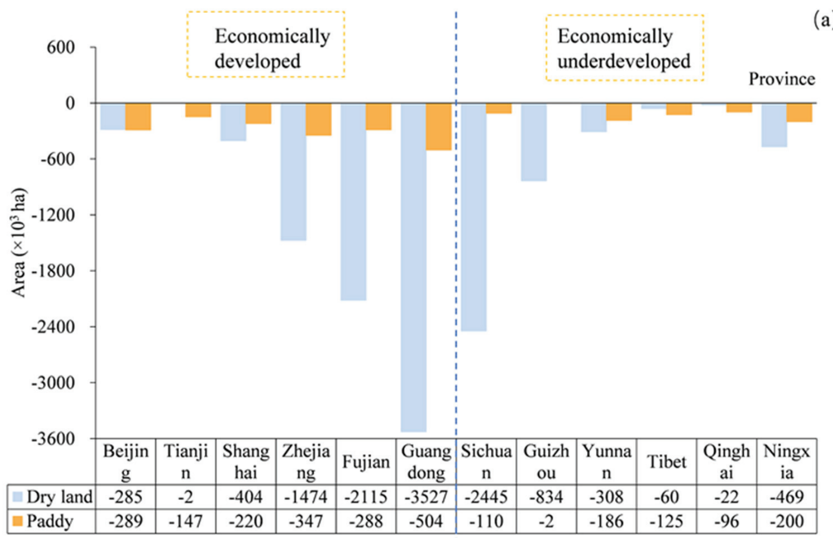
The research data was based on 2018, and the data sources mainly include China Statistical Yearbook, China Agricultural Statistical Yearbook, China Food Industry Yearbook, China Sugar and Wine Yearbook, China Agricultural Products Processing Yearbook, and China Brewing Industry Yearbook. The information obtained includes unit area production of various grain by region, sown area, per capita consumption of major food items in households by region, number of resident population by region, annual production of pork, poultry meat, beef and mutton, eggs, milk and aquatic products by region, and information on annual production of liquor, beer, alcohol and MSG by region.

3. Results

3.1. The Results of Cross-Regional Occupation and Supply of Cultivated Land Areas

Due to the variability in natural endowments, consumption habits and related industries, the cross-regional occupation and supply of arable land resources in 31 provinces in China have obvious spatial heterogeneity. Guangdong Province has the largest cross-regional occupation areas of arable land with 4.03×10^6 ha. Heilongjiang has the largest supply with 6.8×10^6 ha, followed by Henan Province with 3.1×10^6 ha. The 31 provinces involved in the study can be divided into three groups according to the cross-regional occupation and supply of arable land.

Both dry land and paddy field are negative in the first group (Figure 2a). In other words, neither of their own arable land area can meet the demand, and they occupy the arable land areas of other provinces in the process of food consumption. This includes 12 provinces, including Beijing, Tianjin, Shanghai, Zhejiang, Fujian, Guangdong, Sichuan, Guizhou, Yunnan, Tibet, Qinghai and Ningxia. A more pronounced polarization occurs among them. Provinces such as Beijing, Tianjin, Shanghai, Guangdong, Zhejiang and Fujian are economically developed, attractive to talent and have a large resident population. In the process of economic development, more of its land has been used for the development of secondary and tertiary industries, with a small agricultural population and a low food self-sufficiency rate. Yunnan, Qinghai, Tibet and Ningxia, on the other hand, have relatively low levels of economic development and serious population loss. Some regions are also limited by natural conditions. For example, Tibet is located on the Qinghai-Tibet Plateau with complex topographical conditions. The arable land area is small and has to occupy the land of other provinces across the region.



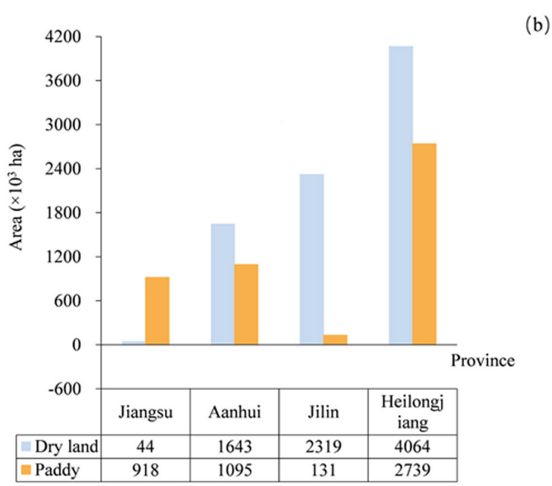


Figure 2. *Cont.*

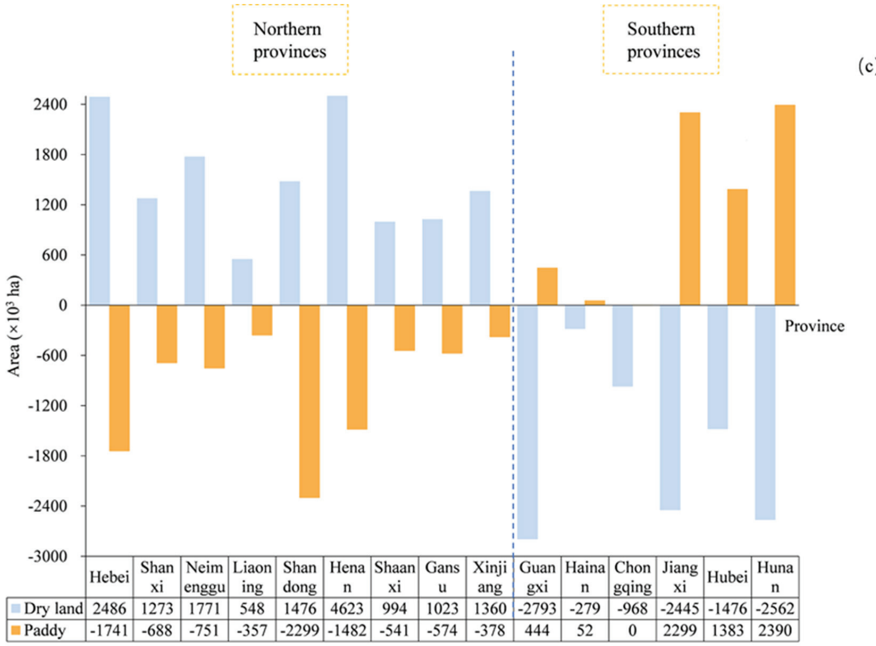


Figure 2. Cross-regional occupation and supply of cultivated land areas between Chinese provinces. (**a**) The first group, (**b**) the second group, (**c**) the third group.

The second group is provinces with positive values for both dry land and paddy fields (Figure 2b). In other words, their dry land area and paddy field area can not only meet their own needs, but also supply other provinces across the region. There are only four such provinces, namely Jilin, Heilongjiang, Jiangsu and Anhui. They all have strong advantages in agricultural resources and belong to the traditional large agricultural provinces.

The third group is one positive and one negative for dry land and paddy field (Figure 2c), which means that one type of arable land in the province can satisfy its own demand and the other type of arable land needs to occupy the resources of other provinces. China is divided by the Qinling-Huaihe between the north and the south. There are differences between the South and the North in terms of natural conditions, agricultural production modes, geographical features, and people's living customs. In the north, the arable land is dryland, and the main crops are wheat and miscellaneous grains; in the south, it is mainly paddy field, and the crop is mainly rice. The results of the study show that the provinces north of the Qinling-Huaihe are self-sufficient in terms of dryland area, while rice consumption is greater than cultivation, requiring cross-regional occupation of paddy resources, for example, Hebei, Shanxi, Neimenggu, Liaoning, Shandong, Henan, Shaanxi, Gansu, and Xinjiang. The provinces in the southern region are just the opposite. Their paddy field area is self-sufficient, while the dry land area needs to be occupied across regions. At the same time, the area of paddy land occupied by the northern provinces is basically smaller than the area of dry land supplied by themselves, while the area of dry land occupied by the southern provinces is greater than the area of paddy field supplied by themselves.

3.2. The Results of Assessment of the Value of Arable Land Support Services

There are large differences in the value of support services between dry lands and paddy fields, especially in soil conservation. Table 1 shows that the soil conservation value of drylands is more than 100 times higher than that of paddy fields, while paddy fields are slightly more valuable than drylands in terms of maintaining nutrient cycling and biodiversity. According to Equation (7), the values of support services for dry land and paddy field are ¥4360.32 hm^{-2} and ¥1396.67 hm^{-2}, respectively.

The provinces in the first group occupy both paddy field resources and dry land resources in other areas, so they need to pay the compensation amount. The negative values represent the payments. The provinces in the second group supply both paddy field resources and dry land resources to other provinces, so they should collect the corresponding amount of compensation. The positive values represent the collections (Table 2).

Table 2. The value of supporting services and ecological compensation standards for cross-regional occupation or supply of cultivated land in China's provinces in 2018 (billion RMB).

	Province	Dryland	Paddy Field	Compensation Standard		Province	Dryland	Paddy Field	Compensation Standard
The First Group	Beijing	−1.243	−0.403	−1.646	The Third Group	Hebei	10.841	−2.432	8.409
	Tianjin	−0.008	−0.205	−0.213		Shanxi	5.553	−0.961	4.592
	Shanghai	−1.761	−0.307	−2.068		Neimenggu	7.723	−1.049	6.674
	Zhejiang	−6.428	−0.484	−6.912		Liaoning	2.391	−0.499	1.892
	Fujian	−9.224	−0.402	−9.626		Shandong	6.436	−3.211	3.224
	Guangdong	−15.377	−0.704	−16.082		Henan	20.159	−2.07	18.089
	Sichuan	−10.661	−0.154	−10.815		Shaanxi	4.336	−0.756	3.58
	Guizhou	−3.639	−0.003	−3.641		Gansu	4.462	−0.802	3.66
	Yunnan	−1.342	−0.26	−1.602		Xinjiang	5.93	−0.528	5.402
	Tibet	−0.262	−0.175	−0.437		Jiangxi	−10.66	3.211	−7.449
	Qinghai	−0.096	−0.134	−0.231		Hubei	−6.438	1.932	−4.506
	Ningxia	−2.044	−0.28	−2.324		Hunan	−11.169	3.338	−7.831
The Second Group	Anhui	7.166	1.529	8.695		Chongqing	−4.222	0.0002	−4.222
	Jiangsu	0.19	1.283	1.473		Guangxi	−12.178	0.62	−11.558
	Heilongjiang	17.722	3.826	21.547		Hainan	−1.218	0.072	−1.146
	Jilin	10.114	0.182	10.296		Country			−5.225

As for the provinces in the third group, they need to be discussed separately according to the north and the south (Table 2). Most of the paddy fields occupied by the northern provinces are smaller than the area of drylands supplied out by themselves, and the value of support services in drylands is three times higher than that in paddy fields, so on balance, all northern provinces in the third group are compensated areas. Although the area of paddy field occupied by Shandong Province is slightly larger than the area of dryland it supplies out, it is ultimately calculated that Shandong Province is also a compensated area due to the higher value of dry land support services. The area of dry land occupied by the southern provinces is larger than the area of paddy field supplied out by themselves, and the value of support services for paddy field is lower, so the southern provinces in the third group generally need to pay compensation.

3.3. Accounting for Arable Land Compensation Standard and Its Realization

Based on the results of the arable land support service value assessment and formula (8), the amount of compensation that should be paid and received by each province is shown in Figure 3 and Table 2. Guangdong Province occupies the most value of arable land support services from other provinces with a compensation rate of ¥16.082 billion RMB, followed by Guangxi (¥11.558 billion RMB), Sichuan (¥10.815 billion RMB), Fujian (¥9.626 billion RMB), Hunan (¥7.831 billion RMB), Jiangxi (¥7.449 billion RMB) and Zhejiang (¥6.912 billion RMB). Heilongjiang Province supplies the most arable land support services with 21.547 billion compensated, followed by Henan (¥18.089 billion RMB), Jilin (¥10.296 billion RMB), Anhui (¥8.695 billion RMB), Hebei (¥8.408 billion RMB) and Neimenggu (¥6.674 billion RMB). Although the specific data obtained from the calculations are not identical, these findings are similar in general to those of other scholars [34,35,59–61]. All studies showed that economically developed provinces such as Beijing, Shanghai, Guangdong, Zhejiang, and Fujian are mostly compensated areas, and large agricultural provinces such as Henan, Heilongjiang, Hebei, Anhui, and Jilin are mostly compensated areas. Looking at China as a whole, most of the southern provinces are areas that pay compensation, and most of the northern provinces are areas that receive compensation.

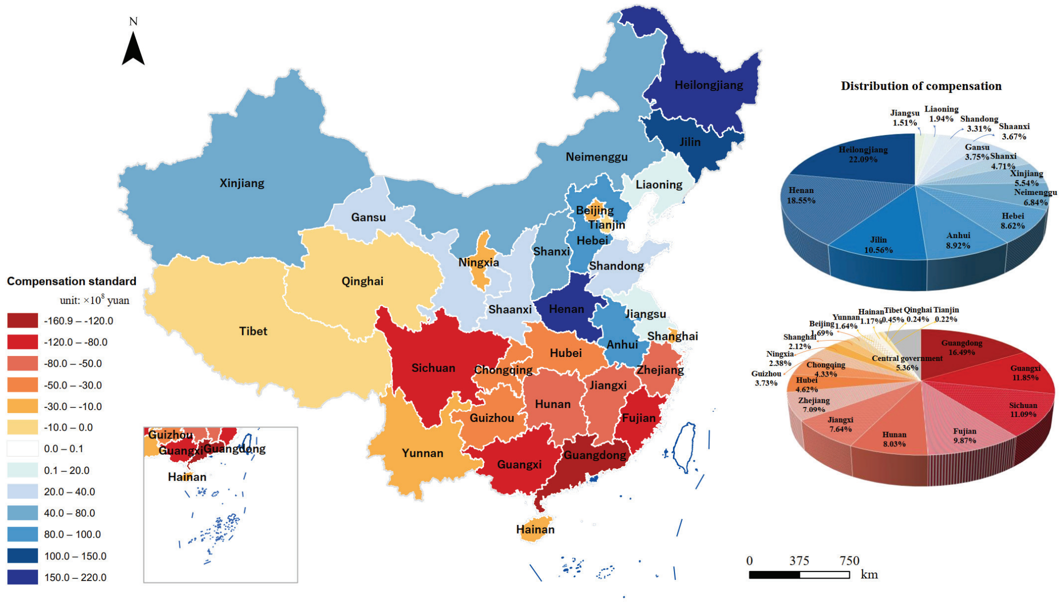


Figure 3. Provincial ecocompensation standard for cultivated land of China in 2018.

Because the study area does not include all provinces in China, and because imports and exports also have an impact on food production and consumption, the calculated amounts of compensation paid and received by provinces nationwide do not exactly match. Due to the lack of statistical data on food flows between provinces in China, it is difficult for us to directly construct a horizontal ecological compensation mechanism between provinces. Therefore, we believe that the arable land compensation mechanism embedded behind food production and consumption could be realized by establishing a national arable land ecological compensation fund. The compensation foundation would specify the subject and object of compensation based on the relationship between the annual production and consumption of agricultural products in each province, and use the supply and occupation of arable land support services by each province to other provinces as the basis for setting standards. The compensation standard would be determined through the valorization of arable land support services. The foundation would collect compensation from the provinces that should pay, and distribute the amount of compensation to the provinces that should be compensated. Finally, the central government would contribute funds to fill the gap between the total amount of compensation received and the total amount of compensation paid. In short, through the establishment of a cultivated land ecological compensation fund at the national level, the country would be considered as a whole, ultimately achieve the purpose of protecting the ecological status of cultivated land and providing institutional guarantees for food production.

4. Discussion

Although modern agriculture has developed towards technology and mechanization, the quality of natural endowments still plays a decisive role in food production and its sustainability. In 2019, Ning conducted a research on the suitable growth areas of China's main staple foods from the perspective of natural resource endowments [59]. In conjunction with Ning's study, we show how the current pattern of grain production in China unifies and diverges from the pattern of natural conditions (Figure 4). At this stage, China's grain production tasks are distributed by province, and many regions have taken on grain production tasks that far exceed their own population needs due to policy, history and variability in economic development levels. However, this high occupancy versus high output production model is not sustainable in terms of natural endowment conditions. Examples include Heilongjiang, Neimenggu, Xinjiang, Shanxi, and Gansu. All of these provinces are located in northern regions with poor light and heat conditions, and their natural endowments rank at the bottom of the country, yet they supply arable land support services to other provinces. Other provinces with superior natural endowments, which should have produced food, have taken up corresponding arable land resources due to economic development or other reasons. This ultimately results in their low self-sufficiency in food production and the need to take arable land support services from other provinces, for example, Beijing, Tianjin, Shanghai, Zhejiang, Chongqing, Hubei, Hunan, Guangxi, and Guizhou. Among these provinces, all of them except Beijing and Tianjin are located in the southern region. It can be seen that the center of food production in China has gradually shifted northward, and northern food transportation to the south has become a significant feature of grain consumption and flow. This has important implications for future research on arable land conservation and its sustainable use, food production and related policies.

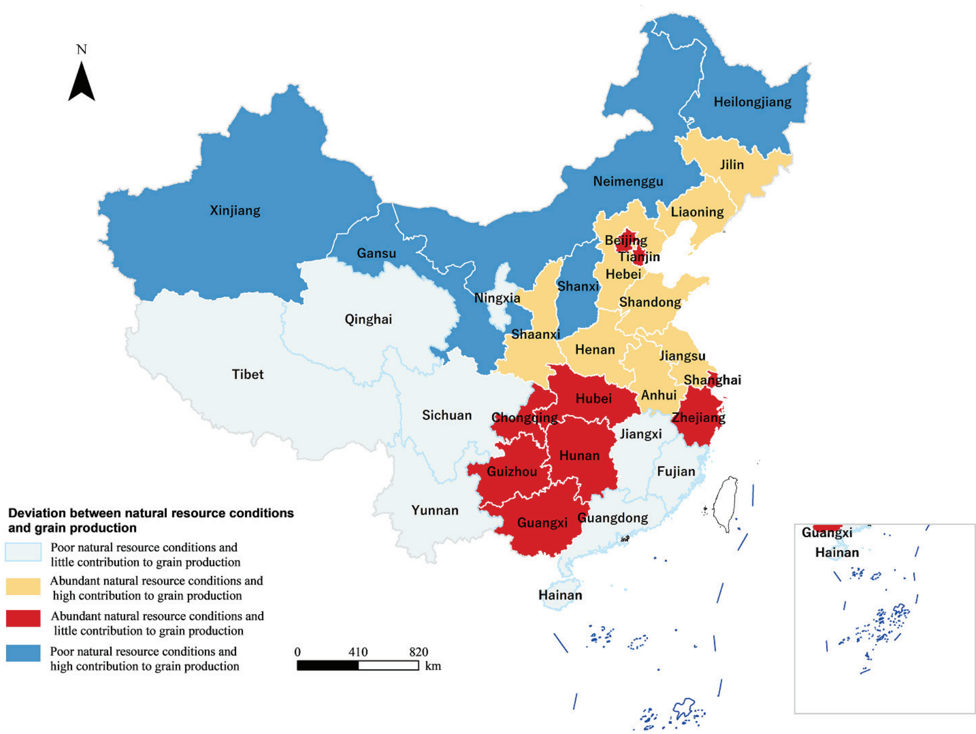


Figure 4. The deviation of China's grain production pattern and natural conditions pattern.

The price of organic food is higher than conventional food, and consumers pay for the "organic environment" by purchasing organic food. Agricultural food also contains inputs of the arable ecosystem support services behind them. In the current market mechanism, the ecosystem services behind food cannot be reflected in the circulation price for the time being, thus requiring us to establish an ecological compensation policy for arable land through administrative means. However, as ecological products become more and more valued, the ultimate goal is to reflect the value of ecosystem services in the price of products and to rely on market mechanisms to ensure the equity of regional development and the sustainable production of arable land.

In addition, the ecological compensation standard for arable land in this study only considers the production, circulation and consumption of three staple foods, while other foods such as vegetables, fruits, quinoa and oats also have an impact on the ecological compensation standard for arable land. Therefore, the significance of this study is to provide a way to compensate arable land and formulate compensation standards that couple the socio-economic system and ecological value systems.

5. Conclusions

In order to protect the arable land ecosystem and ensure food production, this study focused on the pattern of food production, circulation and consumption in China. By revealing the occupation or supply of arable land support services by provinces in other provinces, and the value of support services, the ecological compensation standards for cultivated land in each province in 2018 were calculated. A method for ecological compensation for arable land between regions with the country as the hub was also constructed. The main conclusions are as follows:

(1) The pattern of grain flow in China is mainly from the northern provinces to the southern provinces. Southern provinces mainly supply paddy fields, and northern provinces mainly supply dry land, but overall, the supply of arable land support services in northern provinces is greater than that in southern provinces.

(2) According to the ecosystem service value equivalent method, the support service value of dry land and paddy field was calculated to be ¥4360.32 hm^{-2} and ¥1396.67 hm^{-2} respectively.

(3) The province that needs to pay the most ecological compensation for arable land is Guangdong, with a compensation amount of ¥16.082 billion RMB, and the province that receives the most ecological compensation for arable land is Heilongjiang, with a compensation amount of ¥21.547 billion RMB. The central government needs to pay compensation amount of ¥5.225 billion RMB.

(4) We recommend the establishment of an ecological compensation fund for arable land at the national level. The fund would coordinate the collection and distribution of compensation between regions. Eventually, the ultimate purpose of protecting the ecological condition of arable land, safeguarding the relevant interests of the main food-producing regions, and providing institutional guarantee for food production in China can be achieved.

The results of this study help to explore the mechanisms for achieving ecological compensation of arable land between regions. By combining the compensation with food production and consumption, the value of arable land support services was used as the basis for compensation, thus outlining a path for future research. We can explore the impact of food production and consumption on ecological compensation of arable land in greater depth in the future. Meanwhile, the results of this study reveal the mismatch of China's food production pattern (northern food transportation to the south) with natural resource conditions, which provides reference information for China's food security policy. Subsequent studies may also focus on this point in more aspects.

Author Contributions: Y.B. carried out the experiments and drafted the manuscript. M.L. conceptualized this study, acted as a supervisor and carefully revised the manuscript. L.Y. provided useful suggestions and improved the manuscript. All authors have read and agreed to the published version of the manuscript.

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Article

Mapping the Optimal Rural Areas to Invest in through the LEADER Approach: Case Study—Extremadura (SW Spain)

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Abstract: For more than 30 years, the LEADER approach has been a key tool in the endogenous, local, participatory, and sustainable development of the most disadvantaged European rural areas in demographic and socioeconomic terms. However, despite the unquestionable labor of the rural development policy and the local action groups, various authors, both at a European level and at a national level, in Spain, have concluded that the majority of investments and the greater number of projects through LEADER have been concentrated in the most populated and most developed rural areas. For this reason, there is positive discrimination toward them in the management of aid for rural development. Knowing this and according to the objectives pursued by LEADER, the aim of this work is to analyze the situation in Extremadura (Spain), which has been a beneficiary from the beginning, building an optimal location model for rural development aid. Thus, it will be possible to determine the most convenient, optimal, or priority municipalities to receive aid for rural development due to characteristics such as a smaller population, low demographic growth, low birth rate, high mortality rate, high aging population, low productivity index, high unemployment rates, low accessibility to urban centers, and low LEADER investments in recent years.

Keywords: analytic hierarchy process; Extremadura; LEADER approach; multicriteria analysis; optimal localization model; rural development

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1. Introduction

In 1991, the European LEADER Initiative emerged, executed under a model of integrated, endogenous, and innovative rural development [1,2]. This initiative sought to develop European rural areas through their economic diversification, according to the characteristics and needs of the territory of action, the population that inhabits it, and the exploitation of its endogenous resources [3]. The LEADER approach began as the basis of a pilot project and became an axis of action of the Rural Development Policy 15 years later, continuing its operation today through the management of the local action groups (LAGs) [4], which design the development strategies and manage the financial resources to subsidize the projects. Therefore, for more than 30 years, European rural regions, such as the one covered by this work, Extremadura (Spain), have been beneficiaries of an innovative and alternative development model to the traditional one of public aid management by incorporating the local population in decision making and strategy design [5,6]. As Staic and Vladu state [7], the LEADER approach supports the European objectives for rural development taking into account the territorial dimension and encompassing the principles of bottom-up endogenous development and community empowerment [8]. LEADER is a working methodology based on three parts: strategy, territory, and partnership meant to revitalize and enhance the rural environment through the prominence, autonomy, and responsibility of the rural population [9]. Exactly, the principles of the LEADER approach, which help to understand its operation, are [10]: local development strategies by areas, designed for clearly delimited rural and subregional territories; local partnerships between the public and private sectors or local action groups; a bottom-up approach that gives LAGs decisive power in developing and implementing a local development strategy (bottom-up strategy); cooperation and multisectorial application of the strategy, based on the interaction between agents and projects in different sectors of the local economy; implementing innovative approaches; the execution of cooperation projects; creating a network of local partnerships. Since the creation of LEADER, this approach has worked, with changes attending to the political and territorial needs of the European rural environments, during the following programming periods [4]: 1991–1993 (LEADER I); 1994–1999 (LEADER II); 2000–2006 (LEADER+); 2007–2013 (Axis 4 of the European Agricultural Fund for Rural Development (EAFRD)—LEADER approach); 2014–2020 (LEADER as a participatory local development strategy (PLDS)). In Spain, the country to which the study area of this work belongs, PRODER (Programa Operativo de Desarrollo y Diversificación Económica de Zonas rurales) was created in 1996 to cover all Spanish rural territories, operating under the same parameters as LEADER.

LEADER has generated innumerable benefits [11–15]. However, there are regions, such as Extremadura, which, despite its long history as a recipient of rural development aid, has rural areas that are among the oldest and most depopulated parts of Spain. Its gross domestic product (GDP) is still less than 75% of the European average, and it exhibits lower socioeconomic data than the most dynamic Spanish regions [16]. Since the 1980s, the population of Extremadura has been stabilizing in its places of origin; however, demographic and economic growth is limited to the population centers located in urban and irrigated areas, in their areas of influence, and in places where a productive non-irrigated crop of vines and olive trees is exploited. In contrast, the municipalities with the lowest and aging populations, which are located in the mountain areas, peneplain, non-irrigated areas, and pasture lands in the south of the province of Badajoz, continue to experience demographic losses. Given this, several authors [17–21] have affirmed that, in this region, there are still areas in which LEADER has not generated expected results. These areas have a scarce industrial and business fabric; are far from the main centers of population, leisure, and consumption; and, above all, still have the regressive demographic and social conditions with which they started. Since the beginning of LEADER, the largest number of projects and those with the biggest investments are concentrated in rural areas with more population and development, with a self-sufficient business fabric and with actors capable of co-financing projects. These areas are, mainly, the county seats of the region. Thus, as stated by Nieto and Cárdenas [15], in Extremadura, there is a clear positive discrimination of aid for rural development toward the most demographically and socioeconomically dynamic rural areas. This statement is supported by the results obtained in research on the regions of Andalusia [22,23] and Galicia [24], in the case of Spain, or on other European regions [25,26], highlighting the study of Olar and Jitea [27]. Given the conclusions of these works, as Pérez and Guzmán affirm [28], the good results expected with the implementation of LEADER in various European rural areas seem more of a wish than a reality.

Most of the works cited show, from a quantitative perspective, where the funds are located and concentrated and where the greatest number of projects are launched, leaving in the background those municipalities or regions in which less is invested via LEADER. In the case of Extremadura, this work contributes by identifying the municipalities to which the aid for rural development should go. In other words, this work explains, from a geographical perspective, where the municipalities should be located according to the objective pursued by the EAFRD: to improve the socioeconomic conditions of European rural areas to reduce the processes of aging and depopulation.

Therefore, LEADER investments must be made after analyzing different variables that guarantee an adequate social and economic impact for the protection and development of the rural population that most needs such funds and aid. For this, the implementation of multicriteria analysis methods and GIS tools that facilitate the geographical analysis of a series of selected variables is proposed. These tools and methods will enable making the best decision in accordance with established criteria to assess which Extremaduran municipalities need LEADER and provide them the greatest economic and spatial efficiency; economic, social, and territorial equity; environmental justice; sustainability; competitiveness; quality of life; welfare; and social and territorial cohesion [29–31]. In short, the objective of this work is to determine which areas are the most convenient, optimal, or priority municipalities for receiving aid for rural development because they have regressive characteristics, such as a smaller population, low demographic growth, a low birth rate, a high mortality rate, high population aging, a low productivity index, high unemployment rates, low accessibility to urban centers, and few investments and projects executed under the LEADER approach. This will be achieved by creating an optimal location model as a result of an analytic hierarchy process (AHP) and, subsequently, a weighted overlay multicriteria analysis (WOMA) in a GIS. Information and tools will be generated to direct the scarce financial resources from the EAFRD through LEADER to promote a planning process for rural development in Extremadura.

Multicriteria evaluation (MCE) is a set of techniques used in multidimensional decision and evaluation models [32]. One of the techniques is the AHP, which is used in this research. Saaty, whose objective was to support a reduction in the number of nuclear weapons of the Soviet Union and the USA [33], developed the AHP in the late 1970s. To structure and organize the processes, this method develops a hierarchical structure for decision-making, allows choosing the best alternative from a set of alternatives based on given criteria [34], and helps to mitigate the possible conflicts of subjectivity. Thus, the AHP is considered an internationally accepted weighting method given the advantage it offers by allowing quantitative and qualitative elements to be mixed, enriching the decision-making process [35].

Traditionally, MCE has been applied to the environmental field [36–41], since many factors influence it, but it has also been applied in areas of a social nature [42], such as rural development. Most social problems do not have unique answers but are linked to each other and to what the researcher wants to study. Hence, works that identify optimal sites for locating activities such as tourism [43], public facilities [30,42,44,45], or even social services for certain groups [30,42,44–46] stand out. Extremadura being the study area, MCE has been used for the location of second homes in its rural environment [47]. In addition, there is the work of González-Ramiro et al. [48], in which, through the AHP, they determined the potential of rural tourism in the region. Guillén, Hernández, and Sánchez [49] carried out an interesting application of the process in order to analyze the tourist destinations of Extremadura.

In the preceding decades, the development of the multicriteria evaluation methodology, applied in creating optimal location models in the 1970s [50], and of geographic information technologies (GIT) has led to the search for a combination of both. There are interesting GIS tools of great utility [51] to address, for example, environmental, economic, social, and health issues, such as the WOMA, in a raster environment. In this combination of multicriteria evaluation and the GIS, studies dedicated to decision-making in the territory acquire relevance, especially in solving problems in urban areas [52–54]. Although the use of multicriteria evaluations and their application through the GIS in the social field or human geography has been consolidated over the years, in the case of rural development, it can be considered novel since it has been analyzed, generally, from a quantitative but descriptive perspective and not statistically.

The rest of the article is arranged as follows: Section 2 presents the materials and methods, which encompass the study area, the methodological process, and the location model developed. Section 3 presents the results obtained. Section 4 presents a discussion, and finally, Section 5 presents the conclusions.

2. Materials and Methods

2.1. Study Area

In this work, the study area is Extremadura, a Spanish region located in southwestern Spain (Figure 1). The region is a demographically dispersed territory despite its strategic location on the axis created by the three large metropolitan areas of the Iberian Peninsula [55]. In Spain as a whole, Extremadura is one of the regions with the least diversified and active economies, along with Castilla–La Mancha, Castilla y León, Aragón, and Galicia. These regions are considered "depopulated Spain". With an area of 40,000 km^2, Extremadura has a population of just over 1,000,000 inhabitants, distributed across 388 municipalities. Therefore, its population density is around 27 inhabitants/km^2. Most of the population of Extremadura is concentrated in the main cities: Badajoz, Cáceres, Mérida, and Plasencia. The intense migratory movement after the 60s undoubtedly conditioned the demography of the region, and its consequences are still palpable today, aggravated by the various economic crises suffered in recent decades. Extremadura also has a serious problem of aging in its most rural municipalities, which mainly occupy the spaces located in the mountain and the border areas of the region and which are more disconnected from the main axes of communication with the rest of Spain.

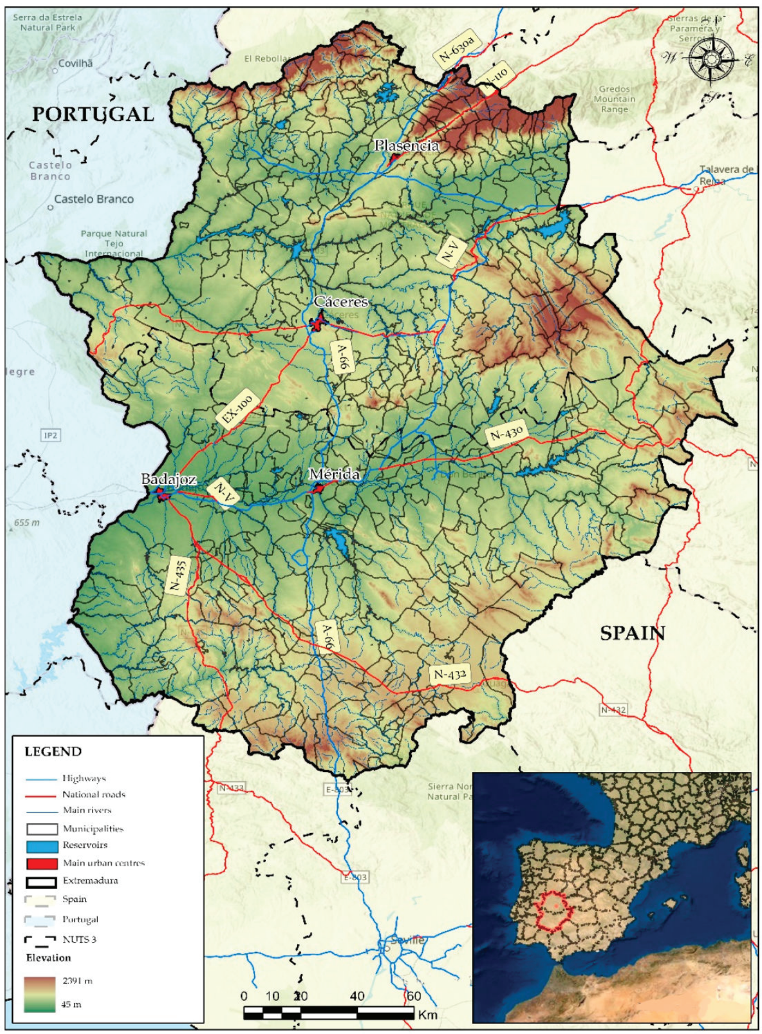

Figure 1. Study area: Extremadura (Spain). Source: Authors.

From an economic point of view, according to the 2000–2020 series of the regional accounts of Spain from the National Institute of Statistics (NIS), the per capita GDP of

Extremadura was 63.5% of the national average in the year 2000, reaching 71.5% in 2010. Afterward, there was a slow increase, and the GDP reached 73.1% in 2018. In 2020, this was the Spanish region that registered the smallest decrease in GDP (−5.2%) compared to the previous year (73.1% in 2019), with EUR 19,304 per inhabitant. Thus, Extremadura is one of the regions whose income has been least affected by the COVID-19 crisis, because it generates the least capital and because it depends less on the most affected sectors, such as tourism or industry. The region converges with the rest of the Spanish autonomous communities in economic terms, but at a slow pace and facing continuous risk due to the danger of depopulation in the most rural areas.

The main socioeconomic characteristics of Extremadura are as follows: the still-high representation of the agricultural sector in the regional GDP (although the tertiary sector, with commerce, tourism, and transport, is the one that generates the most employment), high rates of unemployment, reduction in purchasing power in recent years, low productivity, and high public-sector dependence.

Extremadura presents diverse territories in terms of physical, economic, social, and demographic characteristics. On the one hand, there are areas with a good level of development and with adequate facilities, services, and infrastructures. These areas have a fairly modern and competitive agro-industrial sector and are located in Las Vegas del Guadiana, Valle del Alagón (both with irrigated crops), Campo Arañuelo, and Tierra de Barros (Figure 2). On the other hand, there are areas farthest from the main urban centers, which have a small and aging population and deficiencies in terms of equipment and infrastructure. In these areas, it is difficult for the primary sector to be competitive, and it does not generate sufficient income for its population. These areas are located in the mountainous areas of northern Extremadura and in the peneplain, in the province of Cáceres, as well as on the limits of the province of Badajoz, especially in the south and southeast. Various authors, such as Risco and De la Macorra [56] and Cayetano [57], consider that the low socioeconomic development of Extremadura is mainly due to the inadequate exploitation of its lands, the little transformation of its raw material, the underdevelopment of its infrastructures, the low population, and the low demographic density. Given this situation, it is evident that Extremadura has been a beneficiary of LEADER from the beginning, with 24 LAGs working for its development (Figure 2).

2.2. Methodological Process

This research is characterized by the methodological course proposed and followed, which requires adequate organization. Figure 3 presents the process. First, 10 variables were selected, for which 5 ranges were established. Then, the variables, in vector format at the municipal level, were rasterized and reclassified in a GIS based on the 5 stipulated ranges and that correspond to optimum zones (value 1), very suitable zones (value 2), suitable zones (value 3), acceptable zones (value 4), and unacceptable zones (value 5). It is necessary to take into account that (1) the less population a municipality has, the more optimal it will be for locating LEADER investments and that (2) the higher the birth rate, the more unacceptably valued it will be. Subsequently, before carrying out the WOMA through the GIS, the peer comparison matrix (PCM) and the priority vector (PV) were calculated within the framework of the Saaty AHP to eliminate subjectivities and allocate the appropriate weights to each of the variables/factors. Hence, the optimal location model for LEADER investments in Extremadura was obtained.

2.2.1. Selection of Variables/Criteria and Establishment of Ranges

On the basis of previous studies [17,21,23,58–61] and knowing the geographical characteristics of Extremadura [14,20,57,62–65] related to rural development and LEADER and the objectives pursued by the EAFRD [61,66,67], the variables selected to calculate the optimal location model of LEADER aid and the characteristics to be optimally assessed in the construction of the model are presented in Table 1.

Figure 2. Study area: Extremadura (Spain) and the territorial scope of the LAGs. Source: Authors.

As can be seen from Table 1, from the perspective of rural development, the period 1994–2013 was analyzed, that is, from LEADER II to the European programming period 2007–2013. Prior to 1994, LEADER I was implemented as a pilot and innovative experience in the most disadvantaged European rural areas, such as Extremadura, but in only 4 LAGs, which is why the data were excluded from the analysis. The reason for ending the analysis in 2013 is that it is the last "official" year for which data on projects and investments are available in detail at the municipal level for Extremadura, although in Extremadura, subsidies were managed until the 2015 annuity (due to n + 2) [3]. These data are available thanks to the collaboration of the General Secretariat of Population and Rural Development of the Council of Agriculture, Rural Development, Population and Territory of the Government of Extremadura. For the demographic variables (source: the NSI), the average value was calculated from 2010 to 2020 in order to analyze the influence of the actions of LEADER 1994–2013 beyond its operation. The same method was applied for variables of an economic nature, such as the unemployment rate and the productivity index (source: the Socioeconomic Atlas of Extremadura). Accessibility data were obtained by calculating the minimum access times, through the GIS, for all of the population centers of the rural municipalities of Extremadura and those with more than 10,000 inhabitants, that is, those considered urban according to the NSI [68].

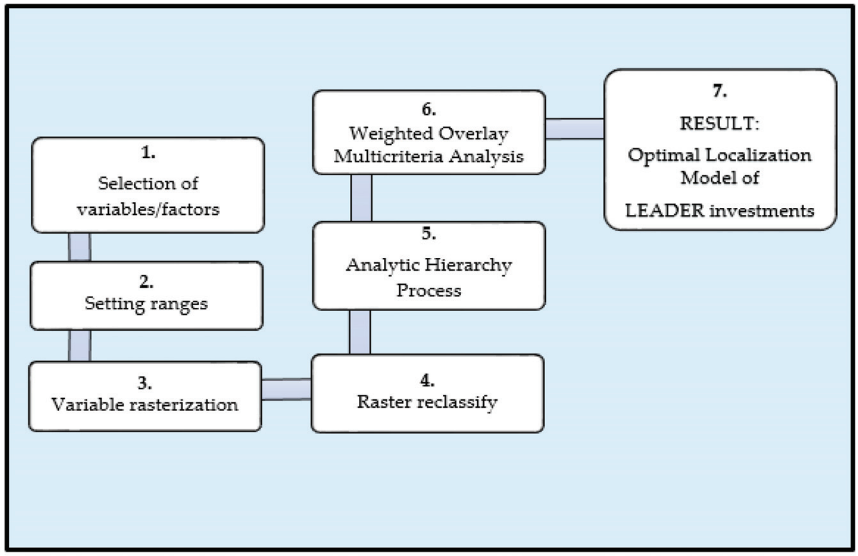

Figure 3. Methodological process. Source: Authors.

Table 1. Selected variables and characteristic to be optimally assessed.

Variable	Characteristics to Be Optimally Assessed
% Population with respect to the total population of Extremadura (average 2010–2020)	Low population
% Population growth (average 2010–2020)	Low population growth
Birth rate (average 2010–2020)	Low birth rate
Mortality rate (average 2010–2020)	High mortality rate
Aging index (average 2010–2020)	High aging index
Productivity index (average 2010–2020)	Low productivity index
Unemployment rate (average 2010–2020)	High unemployment rate
Accessibility to urban centers	Long access times to urban centers
Total LEADER investment in Extremadura (1994–2013)	Low LEADER investments
No. of LEADER projects in Extremadura (1994–2013)	Few projects

All the variables were then assigned to a municipal-based map of Extremadura (source: National Cartographic Base, scale 1:200,000, National Download Center of the National Geographic Institute of Spain) to be processed later in a GIS, specifically ArcGIS Pro. This processing consisted of the rasterization and reclassification of the variables according to the 5 stipulated ranges, detailed in Table 2.

Table 2. Reclassified variables.

% Population (inhab)	% Population Growth (%)	Birth Rate (‰)	Mortality Rate (‰)	Aging Index (%)	Productivity Index	Unemployment Rate (%)	Accessibility (minutes)	LEADER Investments (EUR)	LEADER Projects (Number)	Location Type	Standardized Value
<500	−41–−20	0–4	20.1–93	500.1–4900	0–40	20.1–25.2	>40	0–300,000	0–10	Optimum	1
501–1000	−19.9–0	4.1–6	15.1–20	250.1–500	41–70	15.1–20	30.1–40	300,001–500,000	11–30	Very suitable	2
1001–2000	0.1–5	6.1–8	10.1–15	150.1–250	71–100	10.1–15	20.1–30	500,001–1,000,000	31–50	Suitable	3
2001–10,000	5.1–20	8.1–10	5.1–10	100–150	101–500	5.1–10	10.1–20	1,000,001–6,500,000	51–70	Acceptable	4
>10,000	>20	>10	0–5	<100	501–4900	0–5	0–10	>6,500,000	>70	Unacceptable	5

2.2.2. Analytic Hierarchy Process

Saaty, who formulated a simple tool on the basis of his military research and teaching experience to help decision-makers, developed the AHP in the late 1970s. It is a simple but effective tool, something evidenced in the multitude of applications in which important results have been obtained [69,70], and was designed to structure, measure, and synthesize. Despite the fact that it was created so long ago, it still has a significant impact both theoretically and in application. Saaty proposed to develop a hierarchical structure of the decision problem to structure and order the entire decision process. Thus, he designed it to quantify judgments or opinions about the relative importance of all conflicting criteria used in decision-making [71]. As per the methodology, first, the decision problem was broken down into a hierarchy of interrelated elements, identifying (1) the general objective, (2) the criteria, and (3) the possible alternatives. In this paper, the decision problem is defined by the following hierarchical structure:

(1) General objective: To identify the optimal municipalities for locating LEADER investments.
(2) Criteria: The demographic and socioeconomic characteristics of Extremadura and the results obtained to date from LEADER in the municipalities of the region.Subcriteria: Percentage of population, population growth, birth rate, mortality rate, aging index, productivity index, unemployment rate, accessibility of rural municipalities to urban ones, total investment of LEADER, and total number of LEADER projects.
(3) Alternatives: Optimal location, very suitable location, suitable location, acceptable location, and unacceptable location.

Once the hierarchical structure of the decision problem was established, the PCM was built, which allowed analyzing the degree of importance of each subcriterion with respect to the others. This degree of importance was identified by quantifying or rating the relative importance of the subcriteria on the basis of Saaty's own AHP methodology and according to our subjectivity as researchers of rural development in Extremadura, although in favor of the search for the most reasonable solutions [71,72]. Thus, the importance rating was constructed by the authors of this work based on the empirically accepted Saaty's fundamental scale [73,74]. In this way, the PCM with the 10 subcriteria was built on the basis of the scale of importance shown in Table 3.

Table 3. Importance rating for the construction of the PCM.

1=	If criterion "x" is equal in importance to criterion "y"
2=	If criterion "x" is slightly more important than criterion "y"
5=	If criterion "x" is significantly more important than criterion "y"
7=	If criterion "x" is much more important than criterion "y"
9=	If criterion "x" is absolutely more important than criterion "y"

Once the numerical values of the PCM (Table 4) was calculated, according to the AHP, the PV of the matrix was measured, which provides the weighting of each subcriterion. In other words, the components of the PV of the PCM represent the weights that correspond to each variable in the final decision-making and with which the GIS-weighted superposition will be carried out with map algebra. However, prior to calculating the PV of a matrix, it is necessary to generate the normalized pairwise comparison matrix (NPCM) (Table 5).

Table 4. Pairwise comparison matrix (PCM).

	% Population	% Population Growth	Birth Rate	Mortality Rate	Aging Index	Productivity Index	Unemployment Rate	Accessibility	LEADER Investment	LEADER Projects
% Population	**1**	1/5	1/5	1/5	1/5	1/2	1/2	1/5	1/2	1/2
% Population growth	5/1	**1**	1/2	1/5	1/5	1/2	1/2	1/2	1/2	1/2
Birth rate	5/1	2/1	**1**	1/2	1/5	1/2	1/2	1/5	1/2	1/2
Mortality rate	5/1	5/1	2/1	**1**	2/1	2/1	2/1	1/2	2/1	2/1
Aging index	5/1	5/1	5/1	1/2	**1**	7/1	7/1	1/2	2/1	2/1
Productivity index	2/1	2/1	2/1	1/2	1/7	**1**	2/1	1/2	1/5	1/5
Unemployment rate	2/1	2/1	2/1	1/2	1/7	1/2	**1**	1/5	1/5	1/5
Accessibility	5/1	2/1	5/1	2/1	2/1	2/1	5/1	**1**	5/1	5/1
LEADER investment	2/1	2/1	2/1	1/2	1/2	5/1	5/1	1/5	**1**	1/2
LEADER projects	2/1	2/1	2/1	1/2	1/2	5/1	5/1	1/5	2/1	**1**

Table 5. Normalized pairwise comparison matrix (NPCM).

	% Population	% Population Growth	Birth Rate	Mortality Rate	Aging Index	Productivity Index	Unemployment Rate	Accessibility	LEADER Investment	LEADER Projects
% Population	**1**	0.20	0.20	0.20	0.20	0.50	0.50	0.20	0.50	0.50
% Population growth	5	**1**	0.50	0.20	0.20	0.50	0.50	0.50	0.50	0.50
Birth rate	5	2	**1**	0.50	0.20	0.50	0.50	0.20	0.50	0.50
Mortality rate	5	5	2	**1**	2	2	2	0.50	2	2
Aging index	5	5	5	0.50	**1**	7	7	0.50	2	2
Productivity index	2	2	2	0.50	0.14	**1**	2	0.50	0	0.20
Unemployment rate	2	2	2	0.50	0.14	0.50	**1**	0.20	0	0.20
Accessibility	5	2	5	2	2	2	5	**1**	5	5
LEADER investment	2	2	2	0.50	0.50	5	5	0.20	**1**	0.50
LEADER projects	2	2	2	0.50	0.50	5	5	0.20	2	**1**

After calculating the NPCM, the PV of each subcriterion or variable was generated. This was determined from the weighted sum of each row of the matrix and its average. The result is displayed in Table 6:

Table 6. Priority vector for subcriteria.

Subcriterion	Weighting	Percentage
% Population	0.03	3
% Population growth	0.05	5
Birthrate	0.06	6
Mortality rate	0.15	15
Aging index	0.18	18
Productivity index	0.06	6
Unemployment rate	0.05	5
Accessibility	0.23	23
LEADER investment	0.09	9
LEADER projects	0.10	10

Once the weighting of each subcriterion was calculated, the results obtained were evaluated. For this, Saaty, within the AHP methodology, proposes calculating the consistency ratio (CR) of the matrix from its consistency index (CI) and the random consistency index (RCI) [75]. The CR determines whether the matrix is consistent or inconsistent and whether the values obtained in the PV are adequate or whether adjustments must be made in the comparison matrix to optimize the results. According to the AHP methodology, CR values that exceed 0.10 are a sign of inconsistent judgments, and if they are $\leq$0.10 (for matrixes greater than 5 $\times$ 5), the judgment is acceptable. For the PMC built in this work, the CR was 0.072, so it is very acceptable, considering that it is a matrix of size 10 $\times$ 10. In this way, the results of the matrix analysis and the PV can be validated.

2.2.3. Weighted Overlay Multicriteria Analysis

After reclassifying the variables in raster format according to the numerical scale that represents the 5 ranges or alternatives and after calculating the weighting of each one, the map algebra was carried out in the GIS through the weighted overlay tool.

As intended in this research, the weighted superposition allows multicriteria evaluations to solve decision problems in which several factors, with different evaluations, intervene. This tool combines the following steps: (1) reclassifying the values in the input rasters into a common preference rating scale, (2) multiplying the cell values of each input raster by their importance weight (weights after PV calculation), and (3) summing up the resulting cell values to produce the output raster (Figure 4). Regarding the output values, in this case, high values (on a scale of 1 to 5) indicate that the location is inadequate and low values indicate that the location is very suitable or optimum.

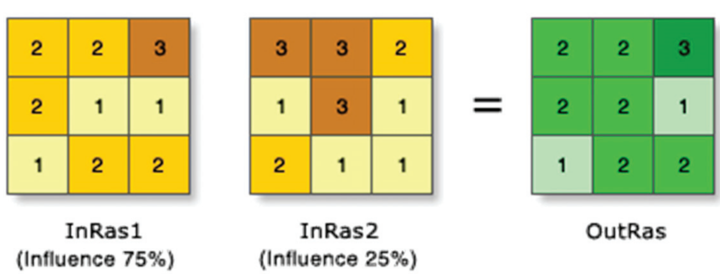

Figure 4. Example of the weighted overlay tool process in ArcGIS Pro. Source: ArcGIS Pro Help.

3. Results

After the previous methodological process, the optimal location model of LEADER investments in Extremadura was obtained (Figure 5). In the model, the municipalities of the region appear according to their value as optimum, very suitable, acceptable, or unacceptable (Figure 6), i.e., which municipalities have the worst data in terms of population, population growth, birth and mortality rates, aging and productivity rates, unemployment rate, accessibility to urban centers, and investments and LEADER projects, and vice versa.

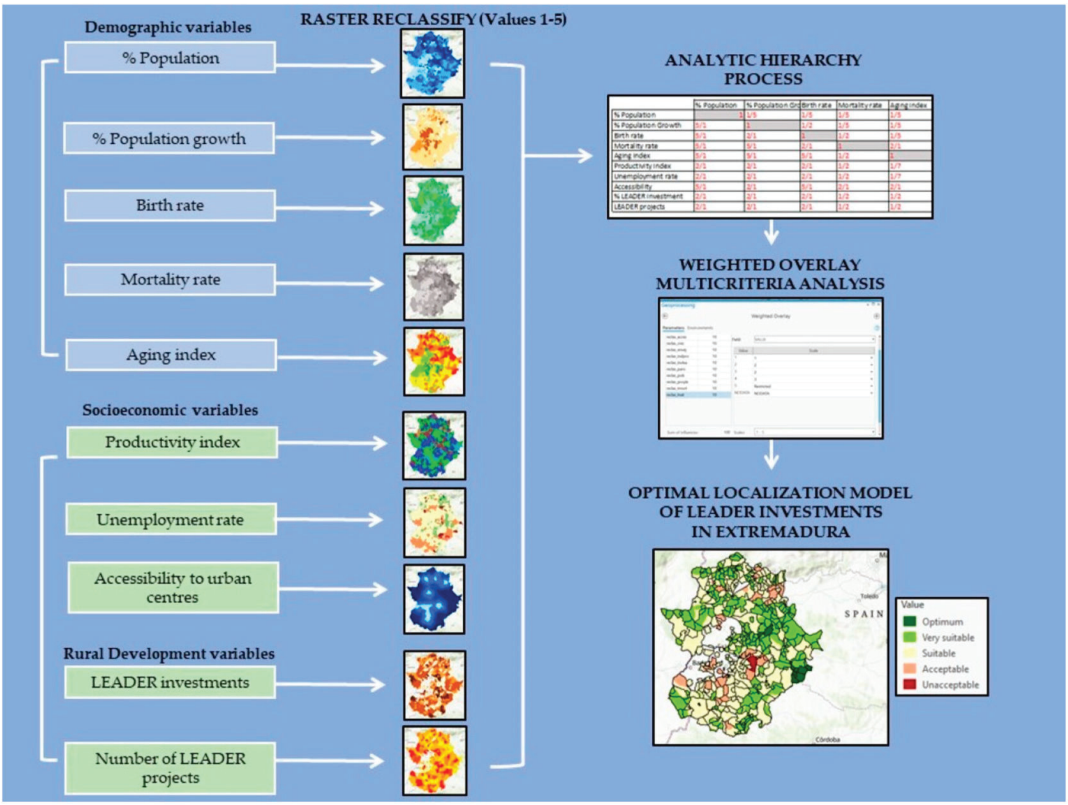

Figure 5. Optimal localization model of LEADER investments in Extremadura. Source: Authors.

Table 7 shows the number of municipalities in each category or an alternative to the model.

Table 7. Number of municipalities by category of the optimal location model.

Zones	No. of Municipalities	% of Municipalities
Optimum	12	3.09
Very suitable	168	43.30
Suitable	179	46.13
Acceptable	28	7.22
Unacceptable	1	0.26

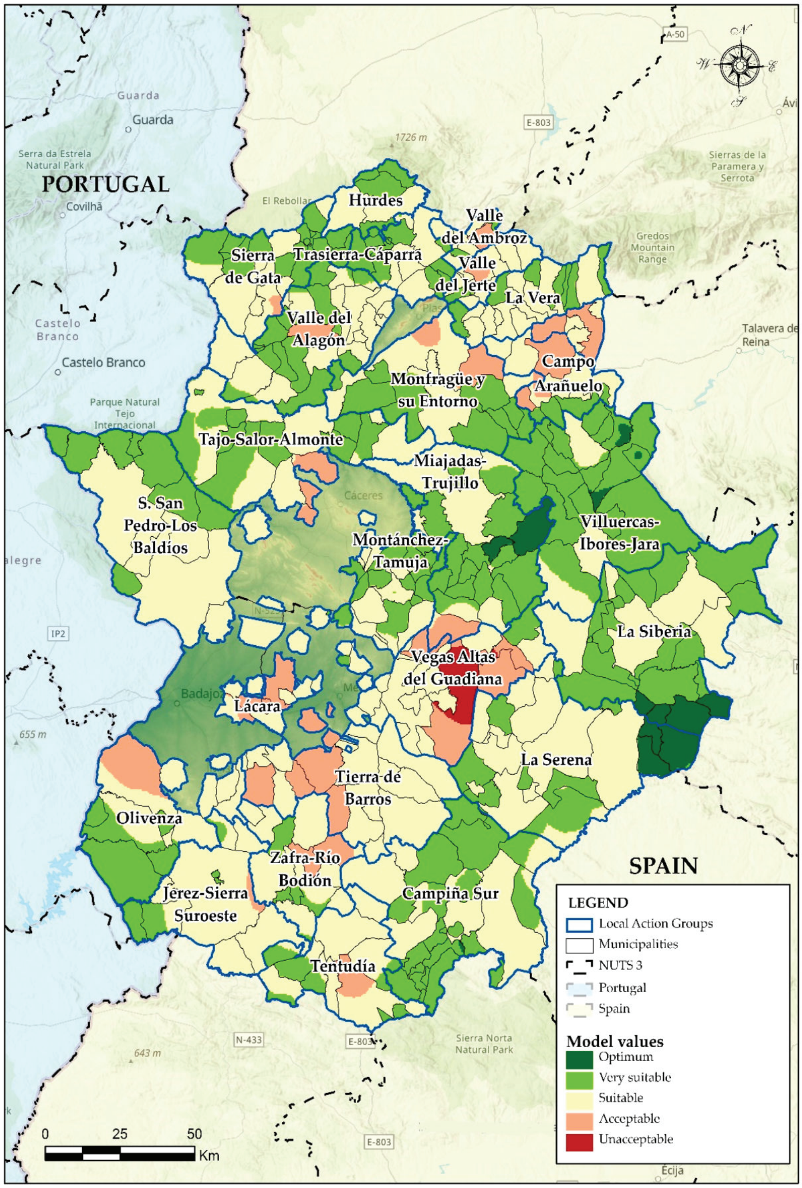

Figure 6. Results of the optimal localization model of LEADER investments in Extremadura. Source: Authors.

There are 12 Extremaduran municipalities that are optimal for receiving aid for rural development due to their regressive demographic and socioeconomic situations and for being the ones that received the least investment from LEADER in the period 1994–2013. These represent 3.09% of the municipalities of the region and are located in Miajadas–Trujillo (2 municipalities), Villuercas–Ibores–Jara (3 municipalities), La Serena (3 municipalities), and La Siberia (4 municipalities). These 12 municipalities are located in bordering territories in the southeast of the region, as can be seen in the location maps displayed in the Section 2.1 (Figures 1 and 2) and in Figure 5. In addition, they are far from the main regional communication routes and those of the main Extremaduran cities and are traditionally the least developed demographically and socioeconomically at the regional and state levels. Along with them, it is necessary to highlight 168 very suitable municipalities (43.30%), which also have unfavorable characteristics, without forgetting the 46.13% that appear to be suitable. In total, there are 359 municipalities for which it would be convenient to bet on the rural development strategy of Extremadura but we are emphasizing those with the worst situation. The 12 optimal ones have had, during the analyzed period, an average population of less than 1000 inhabitants (some of them have less than 200 inhabitants), negative population growth (around −20%), birth rates below 4%, and mortality rates between 20 and 50%. Moreover, they have had aging rates over 500, productivity rates below 70 (the highest value in the region is 9,453, in Belvís de Monroy, in Cáceres), and unemployment rates around 15–20%; require more than 40 min of travel to reach urban centers (due to their border nature within the region and due to the poor conditions of the transport system); and have had an average of four subsidized projects throughout the period 1994–2013, with a total average investment of EUR 169,000. It is necessary to point out that Risco (La Siberia) has not been a beneficiary of any aid in the 20 years analyzed, while Olivenza (protected by the LAG Olivenza), Azuaga (Campiña Sur), and Miajadas (Miajadas–Trujllo) have received more than EUR 13,000,000 million, with 219, 399, and 468 projects, respectively. Furthermore, it is necessary to know that the average number of projects has been 30 and the average investment EUR 1,500,000.

Contrarily, there is one municipality valued as unacceptable. It is located in Las Vegas del Guadiana, and, although it does not have such a high number of projects and amounts invested as in the cases described above, it does have good statistics regarding the demographic and socioeconomic variables introduced in the model. This LAG is located in the most productive irrigated areas of Extremadura and in which, for decades, an important agribusiness has been installed and exploited, which explains why so much is being invested in the area. In this LAG, there is one city, Don Benito, that is, with respect to the number of inhabitants, the fifth city in the urban system of Extremadura, and in the coming years, it will join the neighboring town of Villanueva de la Serena, and they will become the third region city. This will reinforce its character as a focus of economic and demographic attraction at the regional level.

Hence, through the model obtained, it is possible to identify specific municipalities that should be beneficiaries of greater aid for rural development, given that, over the past years, the subsidies have been destined for those municipalities that needed it least because of their demographic and socioeconomic characteristics. In addition, the conclusion can be reached that most of the projects subsidized through the LEADER approach in Extremadura and that large amounts of money have been concentrated in a few municipalities that have the most favorable demographic and socioeconomic characteristics of Extremadura.

4. Discussion

Throughout the years it has been a beneficiary of European aid for rural development, Extremadura has experienced an unequal distribution of aid, even after changing the regulations in the successive programming periods in search of better strategies and fund management. This has been confirmed in various investigations that analyze the functioning of rural development policy in European territory, such as [76–78], and through the results obtained in this study. On the basis of the optimum location model developed, the objective set has been achieved satisfactorily, that is, locating territories that do not receive aid for rural development. From a more economic approach to development, it can be considered logical and sustainable that more development is generated from businessmen and entrepreneurs already settled in each territory [79,80]. However, this causes investments to be grouped in already developed areas, leaving aside the municipalities that most need the implementation of new activities and the diversification of their economies. This same problem occurs, specifically, in the tourism sector. There are studies that reach the conclusion that a large part of the aid for rural development is aimed at rural tourism and that it is significantly concentrated in a few areas [18,81]. For example, it is a problem in coastal areas in Spain [82], where the establishments with better advice and a higher level of infrastructure tend to receive most of the aid at the expense of small rural accommodation, most of which is managed by families, with little training and whose income is complemented by other activities.

Finally, despite the great effort of the LAGs in designing their strategies, the "most powerful" groups and the most solvent businesspeople with prior experience, influence, and power are shaping their ideas. For this reason, studies such as this one are necessary to find out not only where and how the aid is directed but also where it is not. Taking into account the objective pursued by LEADER, it is contradictory that, in Extremadura, the more rural and disadvantages municipalities are the ones that receive the least support from the EAFRD. In order to identify these municipalities, it is necessary to take into account the multiple geographic variables on which decision-making must depend in the design of development strategies. Furthermore, it is essential to choose the most appropriate methods of analysis, such as the ones used in this work: the multicriteria evaluation analysis through the hierarchical analysis process and weighted overlay and the advantages of a GIS for spatial and location analysis.

In this way, applied geography is practiced in the study and analysis of rural development in Extremadura, until now done from a more descriptive perspective [3,14,83,84]. In addition, we approach the purposes of territorial planning and management pursued by the Structural Funds and European Investment Funds (ESI Funds) through "a set of concerted actions to guide the transformation, occupation and use of geographic spaces seeking their economic development taking into account the needs and interests of the population, the potential of the territory and the harmony of the environment" [85]. The multicriteria methods chosen in this study are an excellent tool that can be integrated with GIS instruments since they allow standardizing different types of geographic variables and greater integration that, otherwise, could not be taken into account in decision-making with spatial analysis. Although the methods applied are adequate, it is necessary to take into account that, on occasion, doubts may arise about the type of criteria/factors chosen in the multicriteria evaluation analysis and about the importance given to each one [86]. In this context, the multicriteria evaluation analysis, specifically the AHP, was used as a methodological tool to help decision-making in the fill of rural development in Extremadura to be more consistent, transparent, and legitimate and to avoid variability.

In the field of rural development, and more specifically in the distribution and allocation of public aid, it is vital to have adequate information to make the best decision, and it is a complex and delicate process in which the subjectivity and dependence of the information play a preponderant role. This and the results obtained justify applying true rural development in Europe, and specially in Extremadura, based on the design of strategies that have a multitude of geographical variables that characterize each territory, in order to achieve the desired sustainable rural development that leads to better demographic and socioeconomic conditions for the most ruralized.

Regarding the methodology used, the results of this research show that multicriteria analysis methods together with spatial analysis GIS tools allow obtaining good and adequate results and are versatile and adaptable to various fields of knowledge [87], not only the traditional ones, such as environmental or economic, but also the social and humanities ones, which also encompass problems in which multiple variables intervene, such as rural development. The implementation of rural development policy in Extremadura has been extensively analyzed, but using different methods to the one used in the present research, i.e., Nieto and Cárdenas applied principal component analysis [21] and Local Moran's I and Getis Ord cluster analysis [15], obtaining different groups of municipalities according to LEADER aid and projects. After an extensive search, no studies have been found that analyze rural development through an AHP, which revalues the present one.

According to the objectives proposed by LEADER, it is clear that the results need to be evaluated from a quantitative perspective, for example, in terms of the number of projects. In fact, in Spain, as stated in the Section 1, various regions have been the object of analysis, such as Cantabria [88] and Castilla–La Mancha [89,90]. In these studies, LEADER is analyzed mainly through the basic territorial distribution of aid, the measures to which they are directed, the types of promoters, jobs created, etc., and the results are enlightening, but it is considered essential to relate them statistically with the demographic and socioeconomic context of the territories on which LEADER acts, as is done in this research. On the other hand, others authors, such as Navarro, Woods, and Cejudo [91], study the social aspect of LEADER, as well as Márquez et al. [92].

5. Conclusions

During the last 30 years, an interesting, innovative, and alternative development model to the traditional management of public aid has been applied in European rural areas, involving the transformation and reconstitution of public action through the incorporation of the local population in decision-making processes. Together with it, LAGs have been in charge of the design and start-up of the development strategies of their territories of action and the benefits generated are unquestionable. However, these have not been enough to prevent an unequal distribution of aid for rural development or the fact that some municipalities benefit more than others that have worse demographic and socioeconomic conditions, such as the case of the Spanish region of Extremadura. Nonetheless, in this work, we want to prove that LEADER is more than adequate for the management of rural development aid for its bottom-up approach and for its struggle to involve the population in development processes. Perhaps the rest of the European funds and policies should take LEADER as an example and apply its actions taking into account the needs of the population to feel safe and supported in their regions, as well as working together, since the objectives are the same, speaking then of territorial rather than rural development. For this, the work of the LAGs is essential. They faithfully know the weaknesses, threats, strengths, and opportunities of their territories, so they deserve greater freedom to design strategies and to reduce their bureaucratic burdens. In addition, more EAFRD action measures should be managed under the LEADER approach, so that the entire population, whether farmers, artisans, ranchers, or owners of a restaurant, is economically backed. If the population is aware and participates in the development processes, it will be feasible to bet on their place of origin, keeping the rural environment alive.

It is difficult to find a way to solve the fact that there is an unequal distribution of European funds for rural development in regions such as Extremadura due to the difficult situation of rural areas and the great complexity of the development processes. However, in this paper, a tool is presented that can serve in decision-making and in the supply of aid in an optimal way, so that a demographic and socioeconomic evaluation of the territory of action is necessary before distributing and weighing the projects to be subsidized.

Finally, as a future line of research, one aim is to continue investigating the demographic and socioeconomic variables that characterize rural areas in Extremadura and whether they influence the perception of aid for rural development. The model developed in this research will continue to evolve, since it is also intended to analyze the European programming period 2021–2027 and whether the same trends will continue in terms of aid through the LEADER approach. Thus, it will be possible to provide a tool with which the final distribution of aid is the most logical, fair, and sustainable possible for the benefit of the European rural environment.

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Article

Protected Natural Spaces, Agrarian Specialization and the Survival of Rural Territories: The Cases of Sierra Nevada (Spain) and Alta Murgia (Italy)

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Abstract: In Europe today, there is increasing interest in the management of protected spaces, not only in an attempt to ensure their conservation but also because of their enormous potential for promoting rural development. These protected spaces are generally designed from the top down, although, in an increasing number of cases, they are being promoted by rural communities themselves. The situation across Europe with regard to protected areas is extraordinarily complex due, among other reasons, to the variety of categories and types of protected areas at the regional level. The objective of this study was to compare two parks: the Sierra Nevada National and Natural Park in Andalusia, Spain, and the Alta Murgia National Park in Apulia, Italy, in order to identify any similarities and/or differences between them. To this end, we performed a dynamic analysis of the evolution of the crops, uses, and livestock species using a specific indicator that can detect local dynamics by comparing areas inside the parks with those in the immediate surrounding areas. The results pointed, in part, to a resurgence of these places. In both cases, a trend was observed towards more extensive farming of certain crops and livestock species that are more profitable and/or more highly regarded as quality products. In other cases, there was a risk of traditional crops and agricultural landscapes being abandoned and lost. Various threats were identified in relation to capital-intensive forms of agriculture, especially involving greenhouse cultivation on the Mediterranean coast in the provinces of Granada and Almeria.

Keywords: protected spaces; production specialization; rural development; recovery of the territories; natural parks

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1. Introduction and Theoretical Framework

In recent years there has been increasing interest in the management of protected natural spaces and in enlarging the areas covered by different forms of protection, which are widely recognized, especially in Europe, as a potential driver of rural development.

A general analysis of the different experiences across the world [1] in relation to the protection of natural areas revealed that the enclosure of these areas via the establishment of natural parks often took place through top-down regulatory procedures, involving a series of phases and processes. Rural communities took an active role in defense of their natural spaces, with bottom-up demands for the creation of natural parks as a means of protection and survival in the face of external market forces [2]. Once these parks had been created, locals also took part in the nature protection and tourism-related activities that gradually developed inside them [1,3]. Most of the world's protected areas are open to some form of anthropogenic use. Indeed, the global expansion of protected areas that took place between the late 1980s and 1990s was mainly concentrated in categories with less stringent levels of protection. These include, for example, the natural parks established in

Andalusia in Spain, as well as in other parts of Europe, such as Italy [4,5]. However, an analysis of the different experiences at an international level showed that in the last two decades, contrasting trends could be observed (which perhaps require further study), with a strong shift towards more rigorous protection in East Asia and an opposite trend in Latin America and Mediterranean Europe (Ibidem).

Within this process of growing interest in and expansion of protected areas and parks all over the world, there has been a paradigmatic shift in the objectives, from an initial focus on economic growth to a more recent emphasis on sustainable development within the context of biodiversity protection [1]. There have also been radical changes in the way these areas are managed with a move away from a strict protectionist-type system to one involving the controlled use and enhancement of the protected areas [6,7]. In other words, there has been a move away from a static conservationist approach that differentiates and separates the conservation areas from the unprotected areas towards a more relational, dynamic approach that involves multifunctional participatory planning through cooperation between the different stakeholders and interested parties. This trend is especially evident in Europe in the field of rural development [7–11]. As a result, the traditional paradigm of nature protection is increasingly associated with biodiversity, sustainable regional development, the enhancement of landscapes, and local and identity culture with an innovative approach and participatory planning.

The various case studies of these processes across the world [7,9,10] also show that they are often plagued by conflict and other problems. These range from uncertainty or disputes as to where the boundaries of these areas should be drawn or regarding the specific objectives of each park, which can vary a great deal across the world's different regions. Within the context of the new rural paradigm, there are also differences of opinion regarding the most effective forms of management required to achieve objectives such as the conservation of biodiversity, landscapes, and identity values. These require specific interventions not only because the territorial contexts vary greatly in geographical, economic, social, institutional, and regulatory terms [8] but also because this change often requires the involvement of different actors at different territorial scales within a framework that is affected not just by internal, local forces but also by the global market and wider political events [7]. Within the neo-endogenous approach to rural development [12], although the role of local actors is paramount, stakeholders from outside the immediate region can also play their part. However, as will be assumed in this paper, external pressures and demands are perhaps more important. These require a local response in terms of territorial organization and identity, which varies from place to place.

A different approach is therefore required in which the management of natural spaces and the development of rural areas cannot be viewed as separate issues or, as Hidle [7] argued, by considering only the interests of the state in the management and control of natural parks at the expense of local stakeholders.

However, these territorial contexts are often hampered by the absence or ineffectiveness of specifically programmed local development strategies, not only due to the chronic insufficiency of the financial resources offered by public bodies but also due to the redundancy of territorial governance, which in Italy, as in Spain, sees the parks simultaneously engaged in different partnerships, whose geographical scale, objectives, and vision may be inconsistent with their mission, or worse still, in direct conflict with it, leading to inexorable slowdowns or complete paralysis of their action [13–16]. Natural parks, and indeed most other protected areas, continue to suffer from a lack of participation, not only from local communities and stakeholders [17] but also from decision- and policy-makers, who are not always able to promote and guide the participatory processes that are essential for their success [15,16,18].

This is why the comparative study proposed by Hammer et al. [8] is of great interest here as a means of unraveling some of the key questions. First of all, the definition of protected areas in terms of the categories to which they belong in order to understand the role they play or could play in territorial development processes. In this case, national parks are by definition conceived as instruments of environmental protection, while natural parks are intended more as instruments of sustainable regional development in rural areas [19]. However, this distinction is far from uniform across Europe, as shown by the different cases analyzed in this research [20]. These areas are also affected by the new approach based on sustainable development in which (especially large) protection areas in northern and western Europe are considered tools for regional development. These include, for example, the alpine pastures in Austria or the natural and man-made amenities in natural parks in France, Belgium, and Luxemburg, as well as the agricultural land in Norway and the other amenities collected in the OECD inventory [21]. In some cases, particular emphasis is placed on the preservation of traditional forms of land use and the protection of the cultural values and traditions of these areas. They also seek to encourage sustainable forms of tourism that are close to nature and respectful of it in a bid to achieve the protection goals while promoting alternative forms of development [22].

Although sustainable tourism has a synergistic relationship with protected natural areas, in that it can internalize the positive externalities associated with them through the market [21], tourism could become a critical pressure factor due to the conflicts generated by the increase in accommodation facilities and/or second homes [13] produced by the process of naturbanization. This also interferes with agriculture, irreversibly compromising the ecological and sociocultural value of the area [2].

It should also be noted that some authors consider the phenomenon of naturbanization not only acceptable but even necessary for the development of the rural areas surrounding nature parks [14,23], especially when, as in the two case studies, they are very close to urban areas, and therefore highly attractive for development purposes and easily accessible [23].

Although reconciling conservation and development is a challenging and conflicting exercise, business initiatives based on respect for and promotion of natural heritage appear to be the most effective way of avoiding depopulation and abandonment of the territories surrounding or close to protected natural areas [14]. Conservation policies must therefore be transversal and, above all, capable of integrating priorities from different fields, such as agriculture and tourism, which would support general strategies to combat climate change, based above all on the enhancement of ecosystem services [2].

Protected areas, and national parks, in particular, can serve as the main driver of the development of the surrounding area and of its economic and social regeneration. Since these areas are normally strongly rural, the launch of an accreditation program for the agricultural and/or agri-food products produced in the area would help support farms that find it hard to compete, thus performing a sociocultural function in addition to providing purely economic support [14].

Support of this kind is essential for maintaining the socio-ecological balance inside and outside nature parks. Furthermore, the branding of local food products with the park logo would make them more easily recognizable to consumers, many of whom might be willing to pay a price premium as a means of supporting the economy of the park and its surrounding area. This would also help sustain and/or expand a network of agricultural and craft businesses that are willing to work within the ecological constraints imposed by the protection of natural resources [13,14]. Above all, it is vital to ensure that natural parks do not become desolate, fossilized places in which all change is prohibited. Instead, we must ensure that their formidable heritage reserve [14] creates the territorial capital on which to base new participatory local development strategies [1,2], according to a system that DeFries et al. (p. 1037) [13] define as "small loss-big gain".

The instruments and methods used to manage these areas are also of crucial importance. In this regard, integrated approaches to protected areas can enhance "the multifunctionality of landscapes and rural regions". To this end, these areas must be viewed not only from an ecological or economic perspective but also from a broader vision of sustainable development that encompasses cultural and social aspects. This integrated approach not only preserves existing social and cultural values but also creates new ones.

The maintenance and protection of these new values then become key elements for the economy (in the tourism sector, for example) and for the overall quality of life [8].

The relationship between the protected area, agriculture, and local dynamics, therefore, remains an open question that is widely debated at an international level [21].

National parks, which often have a very rich natural, cultural, agricultural, and social heritage, can act as laboratories for assessing policies for local, community-led, sustainable development based on the endogenous resources of the region. At the same time, they can become "living landscapes" in which agriculture can be complemented with a range of different business activities (tourism, handicrafts, education, culture) by borrowing good practices that have been successfully tested elsewhere [24]. Despite the growth generated in some protected areas due to naturbanization, which, as noted above, mainly affects the areas closest to cities, the abandonment of agriculture and the depopulation of more remote areas continue unabated. Above all, at the turn of the new millennium, there were serious reductions in agricultural areas all over Europe. These were accompanied by an even greater decline in the number of farms. This has brought benefits by favoring the expansion and consolidation of larger, more professionally-managed farms that can compete in increasingly large markets and by increasing the area devoted to woodlands, meadows, and pastures in mountain areas as a result of the fall in the number of livestock farms, especially sheep and goats. However, the aggressive agricultural modernization policies underlying these trends have not succeeded in imposing a uniform, highly productive model of agriculture, which means that, especially in protected areas, small-scale "peasant" agriculture continues to play a fundamental role [25] as a model that is capable of integrating production and the associated ecosystem services [2,26,27].

On the basis of these assumptions, this study aims to compare farming specialization in two protected areas, the Sierra Nevada National Park (Andalusia, Spain) and the Alta Murgia National Park (Apulia, Italy), in order to identify similarities and/or differences attributable to their new status as nature reserves. This will be done, specifically, by considering land use, which could be an indicator of rural/local development dynamics.

The study proposes to assess the effectiveness of the national parks in bringing about a revival of these places and to reflect on the new opportunities and scenarios for rural development. By analyzing the dynamics of farming specialization, we try to identify the areas (groups of municipalities) in which this process is most evident. The results obtained will provide a focus for subsequent research in this field and will help assess to what extent and how this shift in farming (towards more extensive, sustainable, and diversified crops or breeds) has been implemented and what policy implications can be drawn. The most frequent changes include the extensification of farming, the abandonment of farmland, and the loss of traditional crops and agrarian landscapes.

2. Materials and Methods

The study analyses, over a 20-year period between 2 agrarian censuses, the trends in agricultural and livestock farming in the Sierra Nevada National Park (SNP) in Spain and the Alta Murgia National Park (AMP) in Italy. These national parks were specifically selected for various reasons. First, because they are in peripheral, predominantly rural regions of southern Europe, with quite marginal economic conditions, and secondly, because they have a long experience in bottom-up practices, in particular the LEADER approach, and have similar geographical and economic situations, with an increasing number of natural and rural tourism-related activities, particularly in the Spanish case, and a declining farming sector. At the same time, each case study has its own specific structural and social characteristics and has followed its own particular path towards agrarian transformation over time. This makes their analysis and comparison even more interesting in attempting to identify unusual evolutionary dynamics. Moreover, the two national parks selected for the study are of great interest because they contain several medium–large-sized municipalities connected to metropolitan areas, which could be experiencing underlying phenomena of naturbanization (Figure 1).

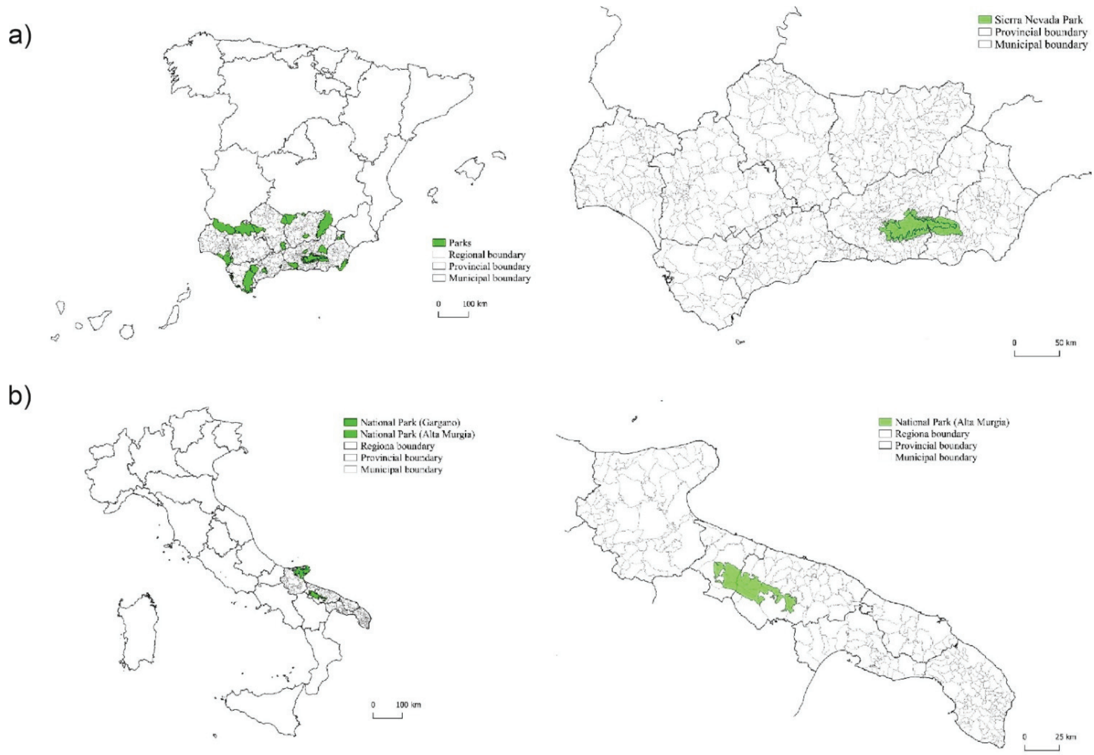


Figure 1. Location of (**a**) Sierra Nevada National Park within Spain and (**b**) the Alta Murgia National Park within Italy. Source: Map drawn by Labianca M.

2.1. Study Areas

2.1.1. Sierra Nevada National Park

The Sierra Nevada Natural Area is made up of a national park and a natural park. It was regulated by Decree 238/2011, which established the Plan for the Management of Natural Resources (PMNR) and the Plan for Use and Management (PUM) for both parks. While the first of these plans has permanent validity and sets out the various possible uses and benefits based on the capacity of its ecosystems, the second plan is open to periodic review.

There are four different levels of protection in the Sierra Nevada National and Natural Parks. In the national park, there are (i) reserve areas—those with the highest level of protection, occupying 0.35% of the almost 86,000 hectares of this park—human land uses are not permitted; (ii) areas with restricted use, which cover 76.1% of the total area and correspond to high mountain spaces largely unaffected by human action and with very limited uses such as traditional agriculture, forestry, and livestock farming, as well as organic, integrated production; (iii) areas of moderate use—mostly agricultural land, covering 23.51% of the total area and more affected by human action; and (iv) areas with a specific use, which are devoted to infrastructure and cover just 48 hectares.

For its part, the natural park is divided into (i) reserve areas, those with the highest levels of protection, which occupy 0.36% of the total surface area (86,355 hectares)—any currently existing agricultural activity that does not alter the surrounding ecosystems is permitted; (ii) special regulation zones (of which there are 4 subtypes), which cover 55.1% of the total area and have a lower level of environmental requirements, allowing forestry, livestock, hunting, beekeeping, and public uses, as long as they do not alter the protected ecosystems; (iii) common regulation zones, covering 44% of the total area, in which farming and housing are permitted, as is the ski resort, the most problematic area. In the farmed areas, there are restrictions on water use and work affecting the landscape, such as the conversion of rainfed land into irrigated land or the movement of soils and rocks for planting new crops. The installation of special systems to protect crops against hail is only allowed at altitudes of less than 900 m. And finally, (iv) the areas excluded from environmental zoning (0.6% of the total area).

The Sierra Nevada mountain range was declared a natural park in 1989, and 10 years later, the highest parts were declared a national park. The protected area covers a total of 172,318 ha, of which 86,435 ha belongs to the natural park and 85,883 ha to the national park. Sixty municipalities belonging to the Provinces of Almería and Granada fall within these protected areas. The Sierra Nevada also contains the highest peak in the Iberian Peninsula (Mulhacen, 3479 m) (Table 1).

Table 1. Sierra Nevada Park: territorial framework of the area.

Variable	**PAR_NAT**		**PAR_NAC**		**BELT**		**Total**	
	2011	**1991**	**2011**	**1991**	**2011**	**1991**	**2011**	**1991**
Altitude (m)	996		667		728		830	
Density (Inhab/Km^2)	27.0	22.6	47.4	38.6	118.1	112.5	74.9	69.5
Population	72,061	60,392	26,475	21,550	392,006	373,258	490,542	455,200
Average Inhabitants/municipality	1638	1373	1655	1347	8522	8114	4628	4294
Masculinization rate (Males/Females) × 100 (%)	103	100	104	100	93	92	95	93
Population over 65 and + age (%)	18.3	16.4	17.4	15.5	17.3	12.7	17.5	13.3
Affiliated to the Agricultural Regime (%)	22.8		28.1		6.8		9.1	
Real Growth (2011–1991)	11,669		4925		18,748		35,342	
Real Growth/year % *	0.88		1.03		0.24		0.37	
Real Growth %	33.0		14.0		53.0		100.0	

Note: * The variable was calculated as follows: Variation in the population over the period/average population × 100 (%)/number of years. Source: Drawn up by the authors on the basis of data from the SIMA (Andalusian Multiterritorial Data System).

The national park covers the area of high peaks and mountains, while the natural park covers the peripheral area surrounding it. This means that the levels of protection and the permitted land uses in each area of the Sierra Nevada vary according to their altitude [28].

The distribution of land uses in the Sierra Nevada is also a result of socioeconomic and political factors. As explained by Jiménez et al. (p. 500) [29], "the policies of reforestation led to a huge increase in the coniferous forest, which has extended into agricultural areas and, occasionally, beyond the existing tree limit. The advance of forested land is attributable also to spontaneous processes of ecological succession (. . .) in parallel to a decrease in human pressure on land". The consolidation and restrictions on land uses imposed by the National and Natural Park Plans have helped drive this trend. At the same time, traditional farming systems, especially terraced crops on the steep mountainsides, are gradually being abandoned.

2.1.2. Alta Murgia Park

Under Italian law (n. 394/91), national parks consist of terrestrial, river, lake, or marine areas containing one or more ecosystems, either intact or partially altered by anthropic intervention, and one or more physical, geological, geomorphological, or biological formations with natural, scientific, aesthetic, cultural, educational, and recreational values of such international or national importance as to require the intervention of the state to ensure their conservation for present and future generations. The Alta Murgia Park, one of the 26 Italian national parks regulated by the Ministry of the Environment, was established in 2004, with an area of over 68,000 hectares, making it one of the largest in Italy. Defined as a special protection area due to the significant biodiversity recognized at the EU and national level, it also includes various interesting natural features such as karst phenomena and steppe habitats (among the largest in Italy), as well as representing a fundamental hub for the national Ecological Network. This national and regional recognition ensures that this area of extraordinary ecological value is seen as an open system that forms part of an extraordinary network with different resources and functions and can be used, from a sustainable development perspective, for a range of economic activities, in particular agriculture and quality tourism, as planned recently by the regional government. In fact, the park area was first recognized as an area of great natural and landscape value in the "Landscape" Thematic Urban Plan of 2000. This plan identified specific territorial areas characterized by a varying level of landscape and environmental values with varying restriction regimes and levels of protection. Later, in 2010, it formed part of the Regional Territorial Landscape Plan, which was better coordinated with existing territorial strategies, and was based on an analysis of the state and the dynamics of the whole territory. In fact, the Alta Murgia National Park falls within the "Alta Murgia" Landscape Area, in which landscape assets relating to hydrological, geological, and morphological aspects of the environmental ecosystem have been identified and mapped, together with the area's cultural heritage, and in particular rural landscapes and their agronomic and cultural characteristics. The area we see today is the result of complex transformation processes over time caused by agricultural, forestry, and shepherding activities. It is part of the vast Murge plateau, characterized by karst phenomena, which was significantly altered by anthropic action, especially during the last century, such as deforestation and stone removal, especially for agricultural purposes. These activities have upset the delicate equilibrium of the ecosystem and caused the loss of typical landscapes [30,31]. The national park includes 13 towns with different socioeconomic situations and growth trends, which could act as connectors with belt areas (see Table 2).

Table 2. Alta Murgia Park: territorial framework of the area.

Variable	PAR_NAT		BELT	
	2011	**1991**	**2011**	**1991**
Altitude (m)	593 (inner hill)		269 (flat)	
Density (Inhab/Km^2)	151	138	545	535
Population	423,224	384,097	745,517	745,186
Average Inhabitants/municipality	32,556	29,546	49,701	49,679
Masculinization rate (Males/Females) × 100 (%)	96.5	96.5	97.4	97.4
Population over 65 and + age (%)	17	13	17	12
Affiliated to the Agricultural Regime (%)	12	18	11	12
Real Growth (2011–1991)	39,127		331	
Real Growth/year % *	0.5		0.0	
Real Growth %	99.0		1.0	

* Note: The variable was calculated as follows: Variation in the population over the period/number of years. Drawn up by the authors on the basis of data from Istat.

2.2. Methods

In the first case (Sierra Nevada), our analysis centered on the period 1989–2009, while in the second (Alta Murgia), we focused on 1990–2010. The (largely irrelevant) one-year lag between the two case studies was due to the different census periods in the two countries.

The study period was chosen in order to enable us to analyze the situation before and after the establishment of the two national parks. The Sierra Nevada National Park (SNP) was established in 1999, and the Alta Murgia National Park (AMP) in 2004. The end year (2009 or 2010) is the date of the last census for which data is available. This allowed us to observe whether the establishment of the national parks influenced agriculture in the municipalities that fell within their boundaries.

Variations in absolute terms in the crops being grown or in the number of livestock being reared only partially reflect the effects of the establishment of a park on the production choices made by farms. This is because these figures fail to grasp the influence of other contextual conditions underlying these changes, such as the decline in the cultivated area and the changes in the relative distribution of this area.

The analysis was conducted using a relative concentration or production specialization index [32] that was capable of recording the increase/decrease in the relative importance of a crop or livestock in a specific territory, independently of any downsizing of the cultivated areas and/or the number of animals registered there.

The Production Specialization Index or *PSI* was calculated for all the municipalities in the Alta Murgia (AMP) and Sierra Nevada (SNP) Parks. The SNP was divided into two distinct sub-areas, formed by the Natural Park (PAR_NAT) and the National Park (PAR_NAZ). In 1989, thanks to the Special Plan for the Protection of the Physical Environment and the Law establishing an Inventory of Natural Areas, the regional government of Andalusia declared Sierra Nevada a natural park, in which only sustainable activities were allowed. In 1999, the highest parts of the Sierra were awarded the highest protection status when they were declared a national park [29].

We will also be looking at the surrounding areas bordering the two parks in order to detect any possible differences between neighboring areas situated inside and outside the park. We will also try to assess how the establishment of the two parks impacted the areas closest to them. The differences in the size of the two parks in terms of both surface area (SNP 1718 km^2 and AMP 680 km^2) and the number of municipalities (the SNP covers 60 municipalities, while the AMP covers 13) also helped us analyze the possible implications of the size of protected areas.

With this in mind, two different datasets were prepared for the years 1989/1990 and 2009/2010 for the two parks (SNP and AMP). The first detailed the different purposes to which the agricultural areas of each park were put (cereals, potatoes, legumes, fruit trees, olive trees, vines, forage crops, meadows and pastures, and vegetable gardens), while the second set out the distribution of the main livestock species (cattle, sheep, goats, pigs, and horses) in terms of their number in each municipality. The latter were normalized by applying specific coefficients (Cattle 0.75; horses 1; sheep 0.11; goats 0.11; pigs 0.3).

For each municipality, we calculated the *PSI* for each crop and for each species by applying the following expression:

$$PSI = \frac{a - b}{(1 - a) \cdot b + (1 - b) \cdot a}$$

in which:

$$a = \frac{x_{ij}}{\sum_i x_{ij}}$$

$$b = \frac{\sum_j x_{ij}}{\sum_{ij} x_{ij}}$$

where:

x_{ij} = area of the crop/livestock (*i*) in each municipality (*j*) of the Parks or Regions to which they belong (Andalusia in Spain and Apulia in Italy).

And *a* is either–(i) the area devoted to each crop as a percentage of the total agricultural area or (ii) the number of each livestock species as a percentage of the total in each municipality in the two parks.

b shows the average percentages for the region as a whole.

The *PSI* can vary between +1 and −1. These values correspond, respectively, to a state of maximum specialization (+1) in which a single crop/species is the only one grown or reared in the municipality or absolute de-specialization (−1) when said crop/species is not grown or reared at all.

In addition to making the evaluation of the degree of specialization/de-specialization in each municipality intuitive with respect to the neutral value (value 0), this index is particularly suitable for the space–time comparisons proposed in this research.

By comparing the *PSI* values for each municipality before and after the establishment of the two parks, we can assess the effects of belonging to a protected area. The constraints that protected status can impose on agricultural production in the area, as well as the new social functions attributed to them, may affect the production systems applied on the farms situated within park boundaries and in the municipalities immediately adjacent to them ("belt" areas), which are also considered in this study.

In order to refine and corroborate the interpretation of these results, we also analyzed the differences in *PSI* values over time using the following expression [32]:

$$PSI^t - PSI^0 = K^0 \cdot \left(a^t - a^0\right) - K^0 \cdot \left(b^t - b^0\right) + \left[\ \left(a^t - b^t\right) \cdot \left(K^t - K^0\right)\right]$$

in which:

a and *b* have the same meaning explained above, while a^0 and b^0 refer to the values recorded at the beginning of the study period and a^t and b^t to the values at the end. $K^{t/0}$ corresponds to the denominator of the *PSI* for the same years:

$$K^{t/0} = \left[\frac{1}{\left(1 - a^{t/0}\right) \cdot b^{t/0} + \left(1 - b^{t/0}\right) \cdot a^{t/0}}\right]$$

By calculating the difference in the *PSI* values registered before and after the establishment of the parks ($PSI^t - PSI^0$), we can obtain a dynamic interpretation of the changes in production specialization (*DPSI*). These can be broken down into three different elements or "components", from which we can obtain a more precise assessment of the influence of the establishment of the parks on the production structure of the farming sector within their boundaries.

The term $K^0 \cdot \left(a^t - a^0\right)$ of the *DPSI* expresses the endogenous contribution to the changes in that it refers to the variations in the shares of each crop/livestock species in each municipality in the park (and in the belt).

For its part, the term $K^0\left(b^t - b^0\right)$ of the *DPSI* expresses the exogenous influence on these changes, as it measures the variations in the shares of each crop/livestock species in the regions (Andalusia and Apulia) as a whole.

Finally, the term $\left[\left(a^t - b^t\right) \cdot \left(K^t - K^0\right)\right]$ of the *DPSI* is a residual component, which assesses the combined influence of the two previous components, and is therefore attributable to the prevailing economic, cultural, and political context.

The results of the analyses can be better understood by visualizing them on a Cartesian plane, in which the *PSI* values for the base year (and the values of the exogenous component of the *DPSI*) are reported on the abscissa, while the final *PSI* values (and those of the endogenous component of the *DPSI*) are reported on the ordinate. The municipalities in which the *PSI* value remains unchanged are on the diagonal line. In the municipalities to the left of the diagonal, the *PSI* values have increased compared to the initial values shown in the abscissa, while in those to the right, the *PSI* values have fallen (Figure 2).

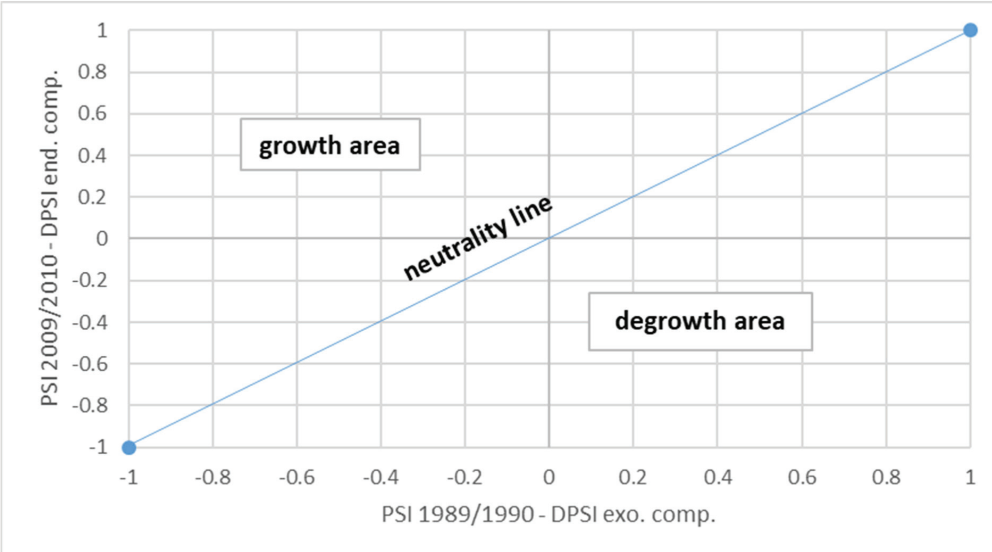


Figure 2. Cartesian representation of the endogenous and exogenous components of the *PSI*. The authors.

3. Results

3.1. Case 1. Sierra Nevada Park (Andalusia-Spain)

3.1.1. Crops

Between 1989 and 2009, the SNP lost almost 3.8% of its UAA (utilized agricultural area) (−3756 ha), 23% of its total farmed area (8649 ha), and almost 62.2% of its farms (−21,770 farms). In both cases, these values were significantly higher than those for Andalusia as a whole, in which UAA fell by 2.8% and the number of farms by 40.0%. Over the 20-year study period, the abandonment of agriculture was, therefore, more intense inside the park. It seems that most of the farms that disappeared were small farms, as manifested in the 61.6% increase in the average size (from 11.3 has to 18.2 has).

While reflecting this overall recessive dynamic, the productive use of the agricultural area of the SNP has evolved quite unevenly over this period (Figure 3). In some crops, such as olive trees and fruit trees, there have even been significant increases. These apparently contradictory results can be explained by comparing the *PSI* values recorded at the beginning and end of the study period, assessing the changes in each crop or species over this period and in their share of the total relative to the other crops or species. These results can also be compared with those for the "belt" area immediately adjacent to it in order to find out whether there are any significant differences attributable to the establishment of the park or other interesting trends.

Trends in the Specialization in Olive Groves (1989–2009)

With regard to olive groves, the comparative analysis of the *PSI* values highlights an increase in specialization (or a reduction in de-specialization) in many of the municipalities in the PAR_NAT area, while de-specialization was more prevalent in the municipalities in the PAR_NAC area. The belt area followed a similar trend to PAR_NAT. Increases can be observed, for example, in the municipalities with traditional olive groves in the Alpujarras region on the southern side of the Sierra Nevada, where the endogenous component is strong. A similar increase in olive cultivation was also observed in another protected mountain range in Andalusia, the Sierra de las Nieves in Malaga. These trends form part of the response of agricultural societies to changes in factors such as farming policies, demographic conditions, and the value system [33]. For their part, any negative changes in the national park may have been due to the stricter regulation of uses, and the abandonment of farmland, especially in the municipalities at higher altitudes and with steeper slopes.

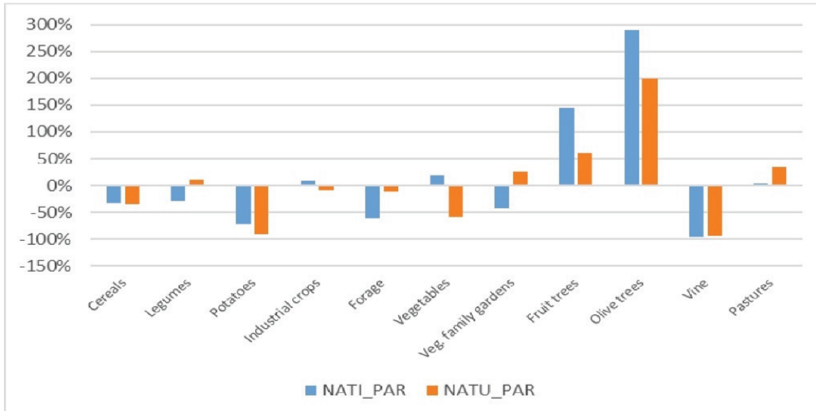
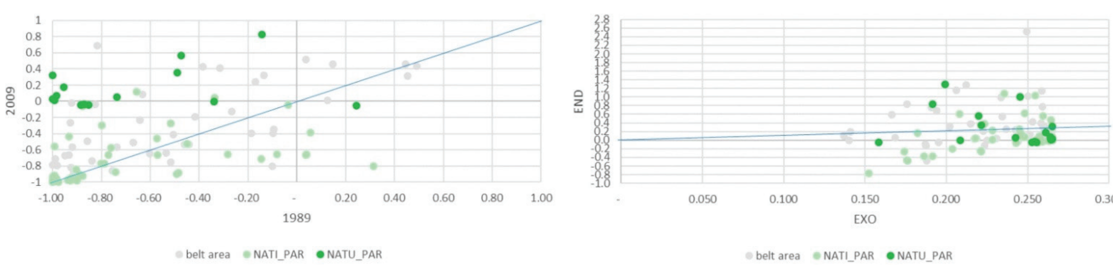


Figure 3. SNP-variation in UAA between 1989 and 2009. Source: Drawn up by the authors using data provided by the 1989 and 2009 Agrarian Censuses, Ministry of Agriculture.

The generalized expansion of the olive grove in Andalusia also led to a degree of specialization in olives in some of the municipalities in the belt area, where the olive groves extend along the borders of the park. This had a clear exogenous component and was also due to the strong support for olive oil production in the 1980s and 1990s.

The dynamic analysis of the *PSI* (*DPSI*) also highlighted that the increases in olive specialization in both the PAR_NAT and the belt areas were mainly of an endogenous nature. This confirms the correlation between the production trends in these two areas. By contrast, the trend in the *PSI* in the PAR_NAC area was mainly influenced by exogenous forces, i.e., variations at a regional or national level (Figure 4a,b).

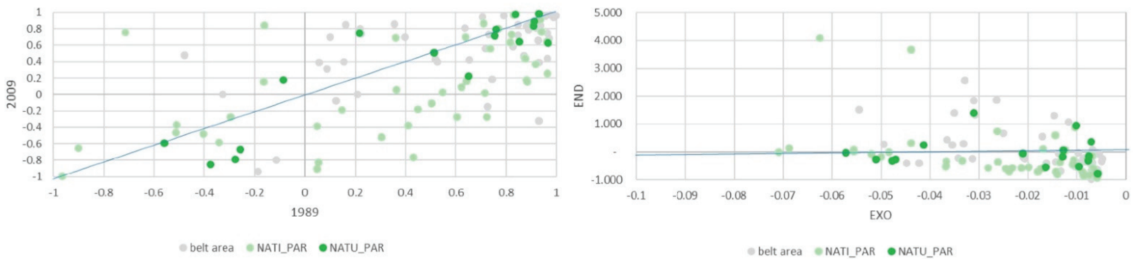


(**a**) (**b**)

Figure 4. (**a**,**b**) Sierra Nevada-*PSI* and *DPSI* for olive tree cultivation. Source: Drawn up by the authors using data from the 1989 and 2009 Agrarian Censuses, Ministry of Agriculture.

Trends in the Specialization in Orchards (1989–2009)

Although there was a slight increase in the share of the UAA devoted to fruit trees in the park area, absolute values fell significantly compared to the base year. This trend was observed above all in the PAR_NAC area but also in the PAR_NAT and belt areas. The dynamic analysis of this index also revealed a clear prevalence of the exogenous component. This suggests that the trends in the specialization in this crop were more influenced by the overall variations observed on a regional scale than by those recorded in the municipalities inside the SNP (Figure 5a,b).

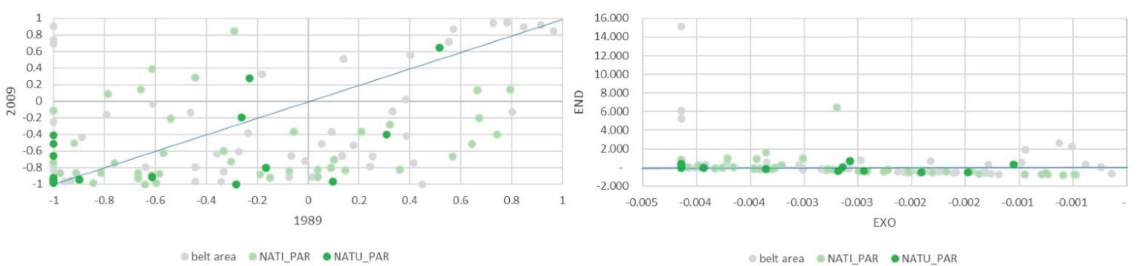


(**a**) (**b**)

Figure 5. (**a**,**b**) Sierra Nevada-*PSI* and *DPSI* for fruit tree cultivation. Source: Drawn up by the authors using data from the 1989 and 2009 Agrarian Censuses, Ministry of Agriculture.

Trends in the Specialization in Vegetables (1989–2009)

The area devoted to vegetables also increased slightly, although it is concentrated almost exclusively in a small number of municipalities in the PAR_NAC area and two municipalities in the PAR_NAT area, all of which are characterized by the dominance (sometimes quite significant) of the endogenous component over the exogenous (Figure 6a,b).

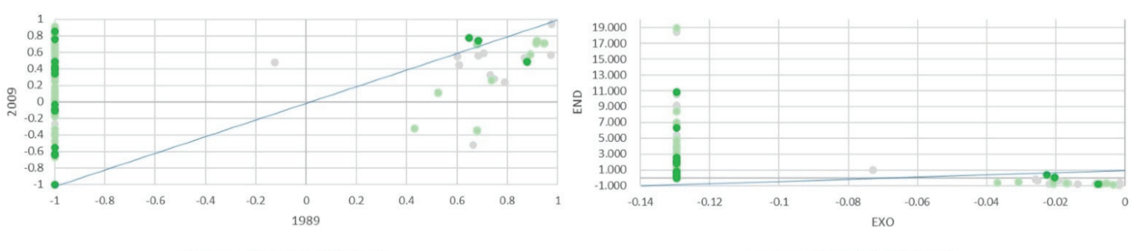


(**a**) (**b**)

Figure 6. (**a**,**b**) Sierra Nevada-*PSI* and *DPSI* for vegetable cultivation. Source: Drawn up by the authors using data from the 1989 and 2009 Agrarian Censuses, Ministry of Agriculture.

Trends in the Specialization in Family Vegetable Gardens (1989–2009)

Despite being a minor part of the total agricultural area, the absolute area devoted to family vegetable gardens grew slightly, above all in the PAR_NAT area. Specialization in vegetable gardens for family consumption increased significantly in both areas of the park, clearly influenced, as might be expected, by the endogenous component of the *DPSI* (Figure 7a,b).



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

Figure 7. (**a**,**b**) Sierra Nevada-*PSI* and *DPSI* for family vegetable gardens. Source: Drawn up by the authors using data from the 1989 and 2009 Agrarian Censuses, Ministry of Agriculture.

Trends in the Specialization in Pasture and Meadows (1989–2009)

The trend regarding specialization in pasture and meadows is also of interest. This category covers land set aside for animals to graze. In addition to significant increases in the absolute areas devoted to this crop, especially in the PAR_NAC area, there was also a clear increase in specialization following the establishment of the park. As can be seen in Figure 8a,b, almost all municipalities have become more specialized in pasture and meadows. By contrast, the municipalities in the belt tend not to specialize in grazing land and, in some cases, have replaced it with other crops.

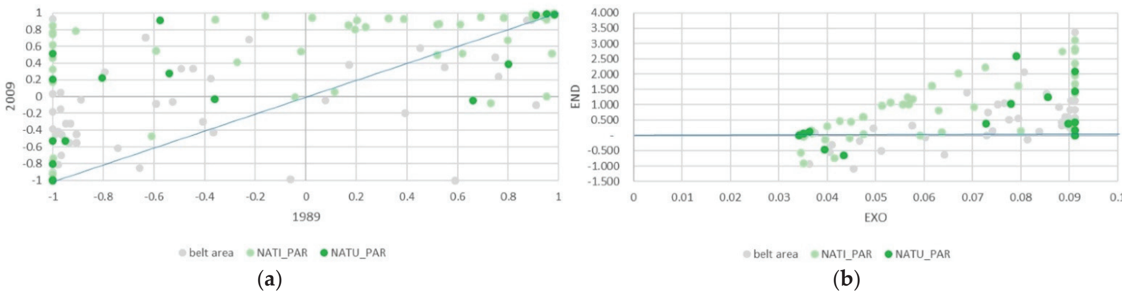


Figure 8. (**a**,**b**) Sierra Nevada-*PSI* and *DPSI* of pasture meadows. Source: Drawn up by the authors using data from the 1989 and 2009 Agrarian Censuses, Ministry of Agriculture.

The endogenous component is also predominant in this crop, as signaled by the increase in the relative importance of this crop inside the park as compared to other agricultural areas.

Trends in Specialization in other Crops (1989–2009)

All the other crops showed more or less consistent negative dynamics, both in absolute terms and in terms of specialization, and in particular, cereals, legumes, potatoes, and industrial crops (Table 3). While the exogenous component had a strong impact on potatoes, legumes, and industrial crops, cereals were most affected by the endogenous component. Vines also declined slightly in both areas of the park, as well as in the belt area, affected by both endogenous and exogenous forces.

Table 3. Trends in specialization according to types of crops (1989–2009).

Cultivation	PAR_NAC *PSI*	PAR_NAT *PSI*	LIM_PAR *PSI*	PAR_NAC *DPSI*	PAR_NAT *DPSI*	LIM_PAR *DPSI*
Cereals	---	---	---	End+	End/Exo	Exo+
Forage	---	--	--	Exo+	End/Exo	Exo+
Legumes	-	--	---	Exo+	Exo+	Exo+
Potato	---	---	---	Exo+	Exo+	Exo+
Grapevine	-	-	+	End/Exo	End/Exo	End/Exo
Industrial	---	---	---	Exo+	Exo+	End+

Meanings: + or – express the intensity the phenomenon: (-) weakly negative; (--) fairly negative; (---) strongly negative; (+) weakly positive. Source: Drawn up by the authors on the basis of data from the 1989 and 2009 Agrarian Censuses, Ministry of Agriculture.

Forage crops deserve to be considered separately due to their close relationship with livestock production. Surprisingly, in that the establishment of the park should have boosted livestock production, these crops showed a recessive trend, in which the exogenous component of the *DPSI* was clearly dominant.

3.1.2. Livestock

As can be seen in Figure 9, there were significant differences between the two areas of the park in terms of the trends in the different species reared (Figure 9).

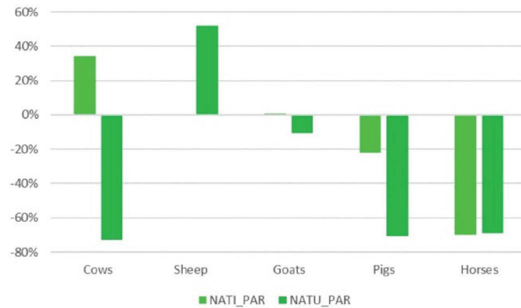
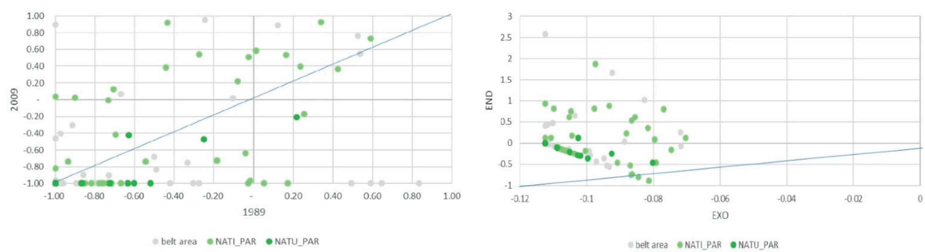


Figure 9. Sierra Nevada-variation in livestock numbers between 1989 and 2009. Source: Drawn up by the authors using data from the 1989 and 2009 Agrarian Censuses, Ministry of Agriculture.

Trends in the Specialization in Cattle (1989–2009)

The clearest example of the contrasting trends in the two areas was in cattle farming, as shown in Figure 10a,b. In fact, the specialization in this species grew quite significantly in the municipalities in PAR_NAC, while most of those in the PAR_NAT and the belt tended towards de-specialization of a mainly endogenous nature.

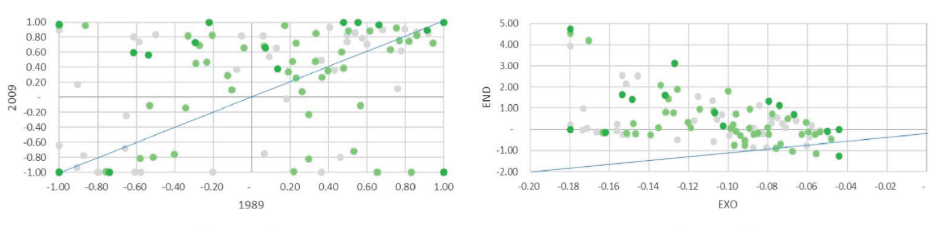


(**a**) (**b**)

Figure 10. (**a**,**b**) Sierra Nevada-*PSI* and *DPSI* for cattle. Source: Drawn up by the authors using data from the 1989 and 2009 Agrarian Censuses, Ministry of Agriculture.

Trends in the Specialization in Sheep (1989–2009)

The increase in the number of sheep over the study period was much more significant in the PAR_NAT area and resulted in a widespread increase in specialization, also in this case, of an endogenous nature (Figure 11a,b).

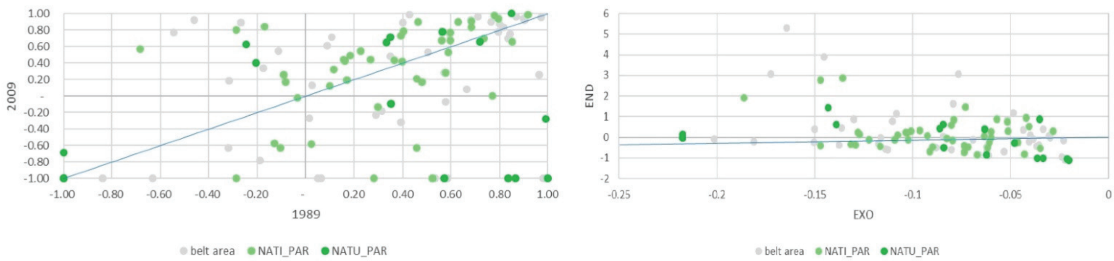


(**a**) (**b**)

Figure 11. (**a**,**b**) Sierra Nevada-*PSI* and *DPSI* for sheep. Source: Drawn up by the authors using data from the 1989 and 2009 Agrarian Censuses, Ministry of Agriculture.

Trends in the Specialization in Goats (1989–2009)

The reduction in absolute terms in the numbers of goat farms is reflected in the rather uneven distribution of specialization in this species in both areas of the park. The increase in specialization over the 20-year study period was mainly influenced by the endogenous component, while de-specialization was largely due to exogenous factors (Figure 12a,b).



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

Figure 12. (**a**,**b**) Sierra Nevada-*PSI* and *DPSI* of goats. Source: Drawn up by the authors using data from the 1989 and 2009 Agrarian Censuses, Ministry of Agriculture.

Trends in the Specialization in Pigs and Horses (1989–2009)

Pig and horse farms declined sharply over the study period, with widespread de-specialization in almost all the municipalities in both areas of the park (Table 4).

Table 4. Trends in specialization according to the types of livestock (1989–2009).

Breeding	**PAR_NAC** ***PSI***	**PAR_NAT** ***PSI***	**LIM_PAR** ***PSI***	**PAR_NAC** ***DPSI***	**PAR_NAT** ***DPSI***	**LIM_PAR** ***DPSI***
Pigs	---	---	---	Exo	Exo	Exo
Horses	---	---	---	Exo	Exo	Exo

Meanings: strongly negative; (---). Source: Drawn up by the authors on the basis of data from the 1989 and 2009 Agrarian Censuses, Ministry of Agriculture.

3.2. Case 2. Alta Murgia Park (Apulia, Italy)

3.2.1. Crops

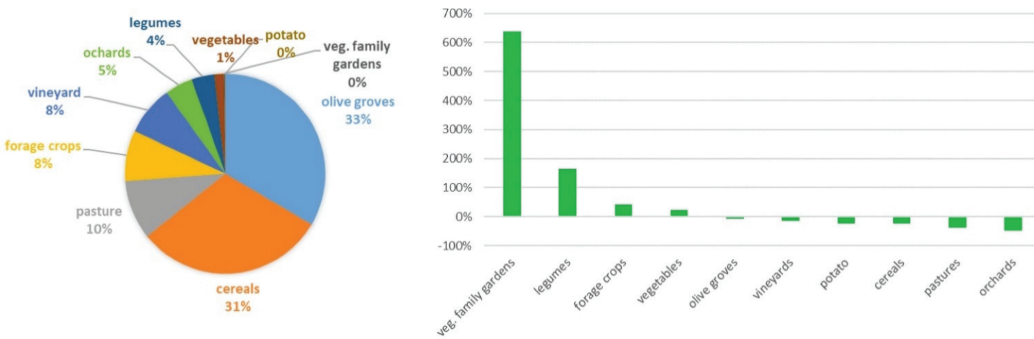
Between 1990 and 2010, the AMP lost almost 15% of its UAA (−167,459 ha) and almost 23% of its farms (−9453). Both these values were significantly higher than those recorded overall in the Apulia region in which the park is located (−12% and −21%, respectively). This large-scale abandonment of farming seems to have hit small farms hardest, as evidenced by the 11% increase in the average size of farms (from 5.54 ha to 6.10 ha).

As occurred in the Sierra Nevada, the general downsizing in the farming sector has been unevenly reflected in the different crops and species, with some faring much better than others (Figure 13a,b). Significant increases can be observed in some crops, such as legumes, fodder, and vegetables, as well as in family vegetable gardens, which despite being a relatively minor category in terms of total agricultural area, could play a fundamental role in the structural transformation of the sector in this area.

In a similar way to those for the Sierra Nevada, we now present the results for the AMP. We also combine the comparative analysis of the specialization in the different crops and species with a comparison between the endogenous and exogenous components of the *DPSI*.

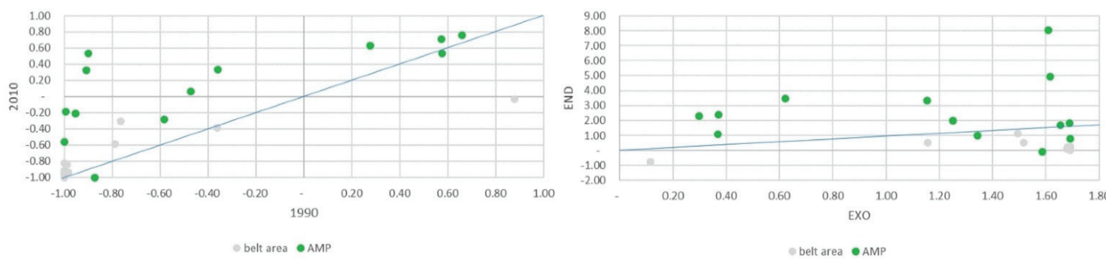
Trends in the Specialization in Legumes (1990–2010)

Legumes represent only 4% of the agricultural area of the park, although the areas allocated to them have more than doubled over the study period (+164%). Significant increases in specialization can also be observed in the municipalities inside the park, although not in the belt area (Figure 14a). In almost all the municipalities in the park, the endogenous component of the *DPSI* prevailed, a sign of the growing importance of this crop in the park area (Figure 14b).



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

Figure 13. (**a**,**b**) AMP-2010 crop distribution and variation in the UAA between 1990 and 2010. Source: Drawn up by the authors using data from the ISTAT.

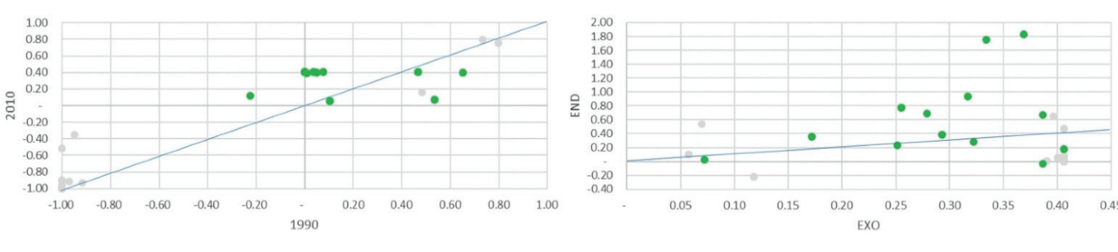


(**a**) (**b**)

Figure 14. (**a**,**b**) *PSI* and *DPSI* for legumes. Source: Drawn up by the authors using data from the ISTAT.

Trends in the Specialization in Forage Crops (1990–2010)

The area devoted to forage crops also increased by 41% over the study period. This increase was manifested in quite varying trends in specialization. Some municipalities in the park that had not specialized in these crops in the base year became more specialized, while others that had been more specialized at the beginning of the study period became less so by the end (Figure 15a). The prevalence of the endogenous component of the *DPSI* (Figure 15b) is a sign of the increasing importance of this crop within the Alta Murgia area.

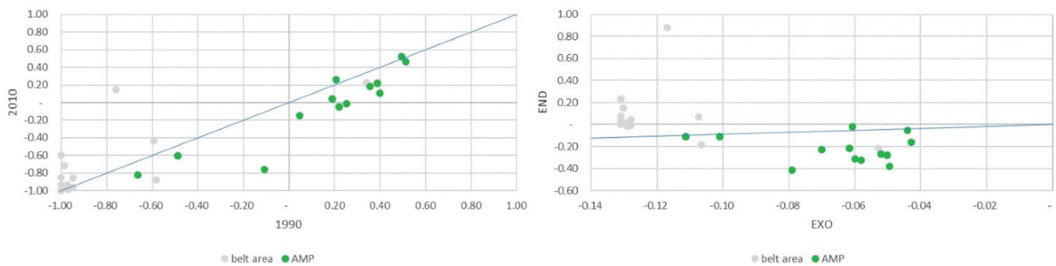


(**a**) (**b**)

Figure 15. (**a**,**b**) *PSI* and *DPSI* for forage crops. Source: Drawn up by the authors using data from the ISTAT.

Trends in the Specialization in Meadows and Pastures (1990–2010)

As regards meadows and pastures (8% of the UAA of the park), there was a widespread reduction not only in the total area devoted to them (−38%) but also in the specialization in almost all the municipalities in the area (Figure 16a). The decline within the park was less significant than in the region as a whole, as demonstrated by the prevalence of the exogenous component of the *DPSI*. This could be attributed to the fact that the establishment of the natural park could have halted the trend toward more intensive farming methods (Figure 16b).

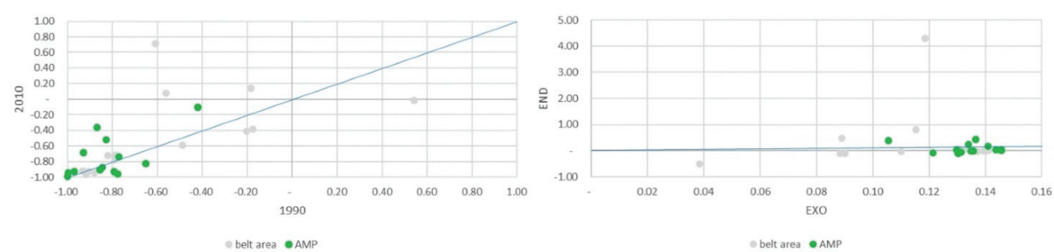


(**a**) (**b**)

Figure 16. (**a**,**b**) *PSI* and *DPSI* for meadows and pastures. Source: Drawn up by the authors using data provided by the ISTAT.

Trends in the Specialization in Vegetables (1990–2010)

Even though the area devoted to vegetables increased by 23% over the study period, the specialization in this crop in the municipalities in the park did not vary significantly, as the *PSI* remained below 0. The weakness of the exogenous component of the *DPSI* in many of these municipalities indicates less significant variations than the regional average (Figure 17a,b).



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

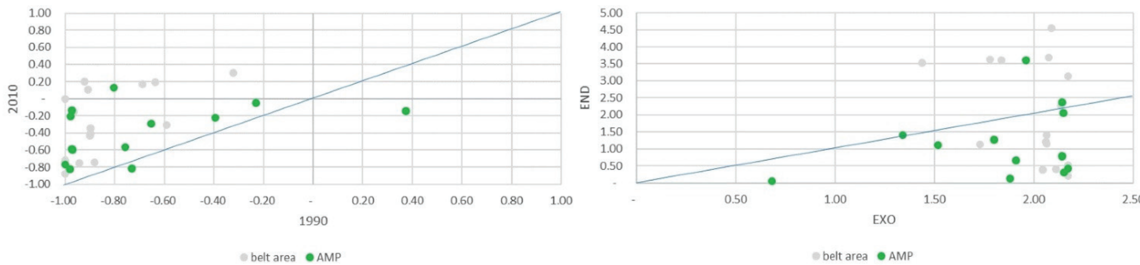
Figure 17. (**a**,**b**) *PSI* and *DPSI* for vegetables. Source: Drawn up by the authors using data provided by the ISTAT.

Trends in the Specialization in Family Vegetable Gardens (1990–2010)

Although there was huge growth in the area devoted to family vegetable gardens (+638%), this did not lead to specialization in the municipalities of the AMP, where this crop continued to play a residual role (Figure 18a). In this case, the exogenous component of the *DPSI* had a stronger influence, as manifested by the fact that the regional average for this category was higher than the average for the municipalities within the park (Figure 18b).

Trends in the Specialization in Cereals and Olive Trees (1990–2010)

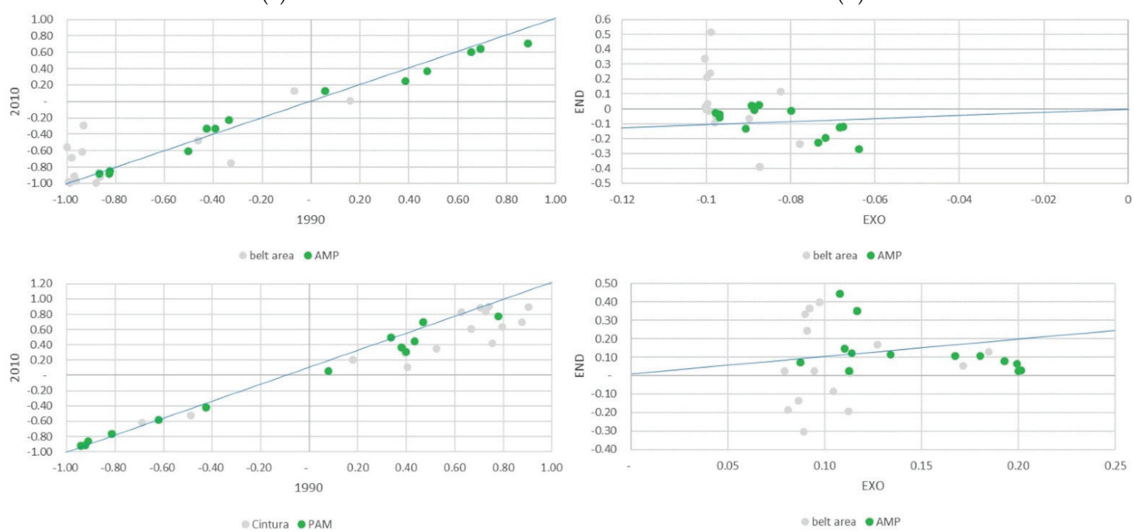
Cereals and olives are the main agricultural crops in the AMP (occupying 31% and 33% of the UAA, respectively). There was a significant reduction in the specialization in these crops in the municipalities inside the park (Figure 19a–d), in line with the reduction in the area devoted to each one (−24% and −8%, respectively).



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

Figure 18. (**a**,**b**) *PSI* and *DPSI* of family vegetable gardens. Source: Drawn up by the authors using data provided by the ISTAT.

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



(**c**) (**d**)

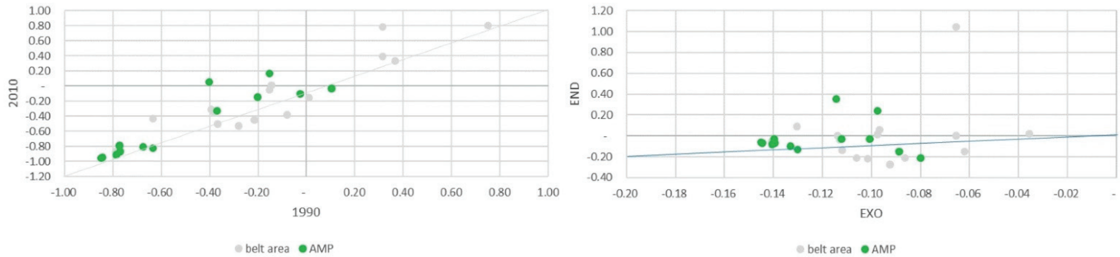
Figure 19. (**a**–**d**) *PSI* and *DPSI* for Cereals and Olive trees. Source: Drawn up by the authors using data from the ISTAT.

Trends in the Specialization in Vineyards (1990–2010)

Although the total area devoted to grape production fell by 13%, there was an increase in the degree of specialization in this crop (Figure 20a), attributable to the endogenous component of the *DPSI* (Figure 20a), i.e., an increase in its share of the land within the park area, as compared to cereals and olives. By contrast, the exogenous component was more influential in cereals and olives (Figure 20b), indicating a loss in their relative importance.

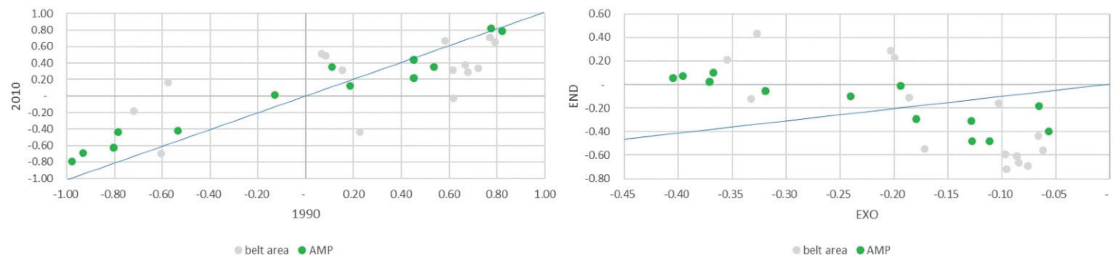
Trends in the Specialization in Orchards (1990–2010)

The last crop in this description of the different crops grown in the AMP is orchards. Even though the area devoted to orchards fell sharply (−49%), there was a generalized increase in their relative importance (Figure 21a), especially in municipalities with a positive endogenous component of *DPSI* (Figure 21b).



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

Figure 20. (**a**,**b**) *PSI* and *DPSI* for vines. Source: Drawn up by the authors using data provided by the ISTAT.



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

Figure 21. (**a**,**b**) *PSI* and *DPSI* for orchards. Source: Drawn up by the authors using data provided by the ISTAT.

3.2.2. Livestock

There were quite uneven variations in the numbers of the different livestock species reared in the AMP over the study period (Figure 22). While increases were observed in cattle and pigs, albeit in different proportions (8% and 144% respectively), there was a slight fall in the number of horses and sheep and a significant drop in the number of goats.

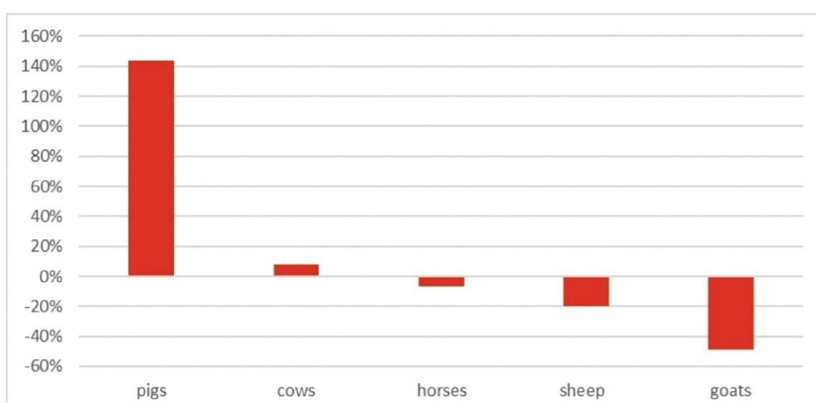
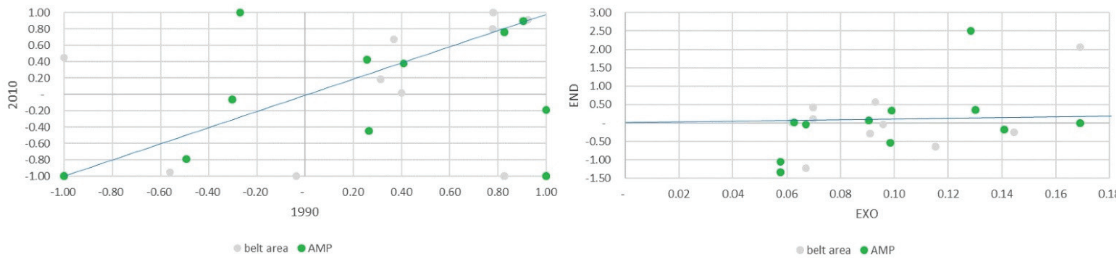


Figure 22. AMP-variation in livestock between 1990 and 2010. Source: Drawn up by the authors using data provided by the ISTAT.

Trends in the Specialization in Cattle (1990–2010)

The increase in the specialization in cattle appears to be concentrated in just a few municipalities in the park, as well as in certain municipalities in the surrounding belt area.

The positive endogenous component of the *DPSI* is a sign of the increase in the importance of this species (Figure 23a,b).

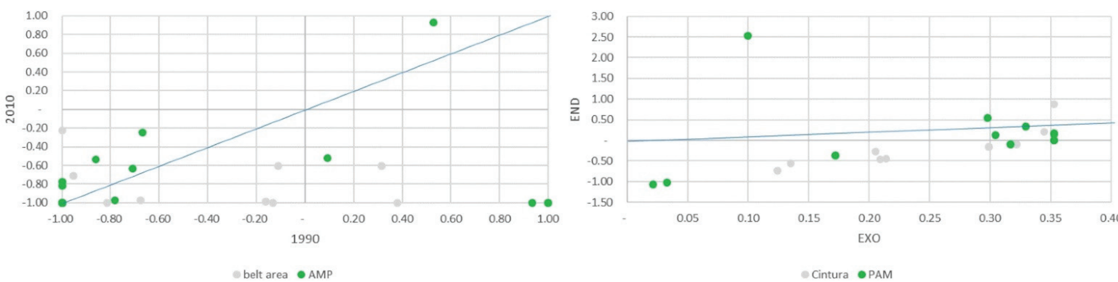


(**a**) (**b**)

Figure 23. (**a**,**b**) AMP-*PSI* and *DPSI* for cattle. Source: Drawn up by the authors using data provided by the ISTAT.

Trends in the Specialization in Pigs (1990–2010)

Despite a considerable increase in the number of pigs reared, strong specialization in pig production was only observed in one municipality in the park (Figure 24a). The dynamics of the *PSI* also seem to be attributable to the exogenous component of the *DPSI*, so confirming the very limited importance of this species for the municipalities in the AMP (Figure 24b).



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

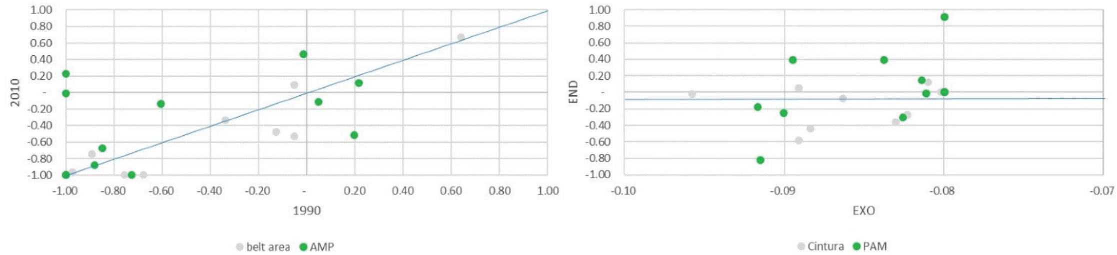
Figure 24. (**a**,**b**) AMP-*PSI* and *DPSI* for pigs. Source: Drawn up by the authors using data provided by the ISTAT.

Trends in the Specialization in Sheep (1990–2010)

The trend in sheep numbers is more interesting in that, despite a significant reduction in the number of animals reared (−20%), at least two municipalities in the park show a strong degree of specialization in sheep farming (Figure 25a). This is manifested in a widespread, endogenous-based increase in the *PSI* (Figure 25b), which reveals the increased importance of sheep farming in the Alta Murgia area.

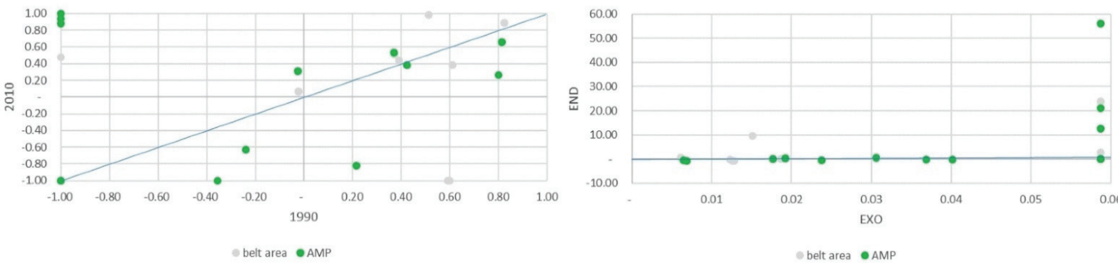
Trends in the Specialization in Horses (1990–2010)

In absolute terms, goat and horse farms play a less important role in the AMP. However, while for goat farming, the 49% reduction in the number of animals did not alter the degree of specialization in this species (de-specialization at both the beginning and the end of the study period), in horse farming, despite an overall reduction of 6% in the number of animals, the degree of specialization in this species increased in some municipalities in this area (Figure 26a), a change that could be attributed to the endogenous component of the *DPSI* (Figure 26b).



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

Figure 25. (**a**,**b**) AMP-*PSI* and *DPSI* for sheep. Source: Drawn up by the authors using data provided by the ISTAT.



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

Figure 26. (**a**,**b**) AMP-*PSI* and *DPSI* for horses. Source: Drawn up by the authors using data provided by the ISTAT.

4. Discussion

In general, the results of our research point to a range of different dynamics and attempts to revive these areas. The main changes comprise an increase in extensive farming, the abandonment of farmland, and the loss of traditional crops and agricultural landscapes driven by market forces and top-down regulations (more evident on the national side of SNP), both at international and regional scales. As Mose [10] and Hammer et al. [8] made clear, the plans for these areas are typically drafted with little involvement by local communities and even less from farmers (whose continued presence in the area and care for it is evidenced above all by the increase in family gardens). The priority objective in both the parks has been the conservation of natural heritage, in particular flora and fauna [29], through various different LIFE programs. However, little work has been done to ensure the multifunctionality or sustainability of agriculture [34,35], the maintenance of agricultural heritage, or the agrobiodiversity of these areas [36], as shown by the influence of the exogenous component in the production specialization/de-specialization processes in the area. In addition to measures aimed exclusively at maintaining material and immaterial values, the conservation of the agricultural heritage in both Sierra Nevada and Alta Murgia also requires other measures aimed at maintaining the uses and activities that have helped produce and sustain this heritage [37,38]. There are certain objectives of effective management that affect the areas both inside and outside the park, in which the needs and objectives of local communities could be better balanced with those of the private sector and public institutions (see meadows and pastures de-specialization). In order to facilitate this, different actors could be involved in different phases (and at different scales) of the planning of projects addressing the important issues facing these areas in the two parks (SNP and AMP), both of which have an important landscape corridor of enormous environmental, social, and cultural value [39].

As Hammer et al. [8] argue, both local institutions and private economic actors and farms play a crucial role, as does the local community, which can facilitate or obstruct the implementation of the programming [40]. Furthermore, the action of individual stakeholders is insufficient, and the establishment of a network system is vital. This can take different forms, which are the precondition not only for the particular forms of protection applied in these areas but also and in particular, for a reticular, participatory planning approach to regional development [41]. Another important aspect is the way in which differing, sometimes conflicting, objectives are reconciled, especially when it comes to promoting local products, in our cases, mainly cattle and sheep at SNP and legumes at AMP. This may require applications for product approval from below, usually from the manufacturers, those most interested in ensuring the product is a success. It may also involve park management and the regional government. These interventions can help improve and add value to traditional, high-quality local products [42]. Official recognition of a product in line with a series of quality principles can provide a huge boost for its brand image, leading to an increase in its production, as happened with the Altamura lentils grown in the Alta Murgia area. This was achieved thanks to the determination of a consortium established by local farmers for the specific purpose of obtaining official recognition and protected status for the Altamura Lentil, which was eventually awarded a Protected Geographical Indication (PGI). This lentil, traditionally considered a product of the family agricultural economy, experienced many ups and downs until the large-scale abandonment of the countryside in the 1970s. It was only fully recovered in the early 2000s thanks to the interest of local farmers, who realized its value as an emblem of the agricultural, historical, cultural, and food heritage of the entire production area. Sierra Nevada, just like Alta Murgia, has a number of officially recognized high-quality products. A few municipalities fall within the area covered by the Protected Designation of Origin for Granada Wines (mostly in the belt area), which has contributed to maintaining this traditional cultivation system in the Sierra Nevada Natural Park and its surrounding areas. There is also the ham produced in the high-mountain village of Trevélez and other predefined municipalities (PGI Jamón de Trevélez). It has a slightly different status in that the territorial quality mark only covers the ham production process, and the pigs do not have to have been reared in the area (as evidenced by the de-specialization in pig production) (You can see: https://www.mapa.gob.es/es/food/topics/differentiated-quality/dop-igp/jamon/IGP_JamonTrevelez.aspx, accessed on 2 June 2022). In the Sierra Nevada National Park, the pasture ecosystems at high altitudes now cover a much larger area due to the intense focus on conserving scarce ecosystems, biodiversity, and rare species of flora and fauna. Currently, 76.4% of the area of the national park is for restricted use only [29]. These restricted uses are partly respon sible for the de-specialization of traditional farming activities (potatoes, cereals, and transhumant grazing) in the high mountain areas. The only activity with an endogenous component is sheep rearing, in which there is specialization in two municipalities associated with the recovery and enhancement of traditional local cheeses.

Similarly, in the Alta Murgia National Park, the territory within the park has several characteristic environments of extraordinary value on a national scale. Many of these have undergone significant transformations over time due to a range of anthropic factors. These include agricultural and pastoral activities, which have played a fundamental role in modifying their structure at both specific and ecosystem levels [31,43]. As transhumant pastoralism became less and less profitable in the Alta Murgia area, more space was devoted to agriculture, grazing, and arable land. In more recent times, the cultivation of more profitable crops such as grapes, olives, and almonds has been extended, contributing to land transformation and the demographic and economic development of the major municipalities [31]. At present, over half the total area is devoted to agriculture with a strong prevalence of arable land, while the remaining part includes wooded areas and semi-natural environments. In particular, especially in recent years, there has been a trend towards the intensification of agriculture in the most fertile areas of the park, while the less productive ones are at risk of abandonment. The greatest decline has been in grazing areas, with some exceptions in municipalities with a strong historical tradition in the cultivation of grapes and olives, especially in the pre-Adriatic Murgian area [42]. This has created a complex territorial system with pronounced differences between the north and south of the AMP and uncultivated areas in which, historically, there has been strong specialization in transhumant pastoralism, which has gradually declined over the last few decades. The decline in this activity has left its mark on the landscape in terms of the reduction in grazing land and an increase in steppe areas with a very small population, confirming the results regarding de-specialization in meadows and pastures as well as in sheep farming.

As happened in Spain, market forces have helped transform agriculture in the Murgia area, with a clear shift from extensive to intensive agriculture (see the specialization in cereals and olive trees), as part of the modernist thrust of the green revolution promoted during the first two decades of the Common Agricultural Policy. This excessive specialization in certain crops lies at the heart of many of the de-specialization processes (especially in cereals) observed over the study period. The intensive removal of stones before the establishment of the park enabled the transformation of about 80% of the pseudo-Mediterranean steppe (a Site of Community Importance of AMP) into cereal crops, a process encouraged by the economic incentives offered by the original CAP, as noted above, and also by the maintenance of a sectoral approach in its more recent editions.

In the Sierra Nevada Natural Park, the permitted land uses are less tightly regulated, which means that traditional crops such as olive trees or vineyards are more likely to be maintained. These peripheral, less protected areas have also hosted an increase in new, more profitable crops, such as organic vegetables and tropical fruits. Having said that, the trend towards crop/species de-specialization revealed by the analysis could indicate an incipient reorganization of both parks towards more extensive, more multifunctional forms of farming. Changes in this direction could be reconciled with the protection of biodiversity and the landscape, especially in the most vulnerable areas and those most exposed to local, national, and international economic forces. To this end, the park authorities could play a key role in reconciling management, protection objectives, and territorial development ones, carrying out the mission assigned to them and favoring the protection and development of the surrounding areas as well. It can also be viewed as a dynamic “living landscape” (as also declared by the Council of Europe [44]) in which a diverse range of economic activities (agriculture, tourism, crafts, education, culture) should be carried out and better integrated, with support from “landscape policies”. This will require strategic cooperation between local and central authorities in line with their specific needs.

As in the case of the Alta Murgia National Park, the current situation in the national and natural parks in the Sierra Nevada is the culmination of a process of degradation of an “evolved” farming system [45] that remained more or less unchanged throughout the 19th century and the first half of the 20th century, before entering a period of sharp decline from the 1950s onwards after large-scale emigration of the area’s population to more industrialized urban areas. Prior to this exodus, the traditional farming system accommodated the increasing population by increasing the irrigated area on the peripheral terraces in the traditional valley areas and by recovering some of the abandoned irrigation channels. In summer, livestock was taken to graze at high altitudes above 1500 m, and irrigation was installed for the cultivation of barley, rye, and potatoes. In this way, irrigated polyculture and rainfed cultivation of cereals, vines, fig trees, and almond trees coexisted with stable forms of livestock farming, in which the farmer reared sheep, goats, and cattle, while also growing a few crops. In other parts of the region, sheep were reared by transhumance, in which the shepherd was often traveling with his flock and could not, therefore, grow crops. In this way, a unique system peculiar to the Sierra Nevada evolved. Bosque and Ferrer [46] described it as a “peasant mountain” farming system, based essentially on Mediterranean polyculture farming, which was very different from the farming systems traditionally found in other mountainous areas of Spain [47,48].

In both parks, industrialization and the consequent rural exodus caused the break-up of this system to the extent that a lot of cultivated land was abandoned due to the impossibility of mechanizing and modernizing small farms in unfavorable areas in an increasingly global market. Cattle farming also declined due to a lack of labor. These problems were exacerbated by the disappearance of other sources of employment and income, such as mining or the paid work available outside the region for farmhands, who would travel around the country to harvest grain and other crops.

This caused a reduction in the number of farms, mainly in inland areas such as those of the two parks. It also brought about changes in their structure and production systems, with the disappearance of large numbers of smallholdings, which made way for larger, more intensive farms. The abandonment of marginal agricultural areas had serious territorial impacts such as the degradation of the environment, an increased risk of fire, and an increase in reforestation [48]. Perhaps the worst side-effect of these changes was the increase in soil erosion, which had been controlled for centuries by the complex networks of water channels, which were well adapted to the terrain, and by careful, sustainable farming of the mountainsides [29].

In this context, the complex, diverse Natural Area of Sierra Nevada (which encompasses both the natural and national parks) and its belt area has significant opportunities, in addition to those already mentioned [49]. The same applies to the Alta Murgia National Park. These opportunities include shifts in consumer demand towards local, handmade, and/or organic products, especially considering that park status could be used as a mark of distinction in terms of the quality and origin of these products while also taking advantage of the growing number of tourists who choose to visit the area. There is also the ancient network of water channels and the associated "careo" system, which are not only a very powerful feature of cultural identity and a unique tourist attraction but also an essential means of water distribution that maintains the landscapes of irrigated polyculture in terraces, the feature most valued by visitors to the area [50,51]. The multifunctionality of these agroecosystems has been institutionally consolidated, and their other inherent functions (environmental, aesthetic, recreational, etc.) are now officially recognized. As a result, specific grants and subsidies are now available, for example, from the CAP [52,53], which remunerates the non-commercial functions of the agricultural activities that sustain these ecosystems [54].

However, these traditional landscapes are also under threat from capital-intensive greenhouse forms of agriculture, which produce high returns and high levels of income and employment in their local area, especially on the fringes of SNP. Unfortunately, they are also a source of negative social and ecosystem externalities [55,56]. Although greenhouse farming has spread a "sea of plastic" along Spain's Mediterranean coast, in both Granada and Almeria provinces, it has not been an issue in the Sierra Nevada until quite recently. In the Natural Park Planning Regulations, greenhouses are prohibited above 900 m of altitude due to their environmental and landscape impacts. Those breaking this rule could be fined by the regional administration. In spite of this, they are becoming increasingly common inside the natural park. This is because this form of agriculture is highly profitable, making it possible for companies located on the coast to accept any fines imposed on them as if they were production costs. Greenhouses are also popular with local farmers based in the natural park, above all because they protect their crops from hail damage. They are also welcomed for the jobs they create [57,58] and have received the backing of the far-right political party (VOX), which passed a motion in the Andalusian Regional Parliament calling for the abolition of the fines imposed on greenhouse farming [59]. This has given rise to a conflict between the conservationist interests defended by the managers of the Sierra Nevada Natural Park, protected by current regulations, and the economic interests of the intensive producers from the coast. Many of these producers are from Almeria and Murcia, where for 4–5 months in the summer it is too hot to grow vegetables on the Mediterranean coast. They can circumvent this problem by building greenhouses in cooler, inland mountain areas to which they can move their intensive production in the summer months. These are often protected areas [39,60]. The park authorities have proposed a number of alternatives to these farmers. These include broadening the cover provided by agricultural insurance, using temporary, removable protection systems in situations of climatic risk, or replacing intensive crops (cherry tomato) with other high-quality crops that are better adapted to this area, such as the "snowflake" potato.

In both parks, the LEADER approach has also made a significant contribution to the rise of rural tourism [61–65]. In the Spanish case, associated activities are particularly popular on the southern side of the mountain range (known as the Alpujarra), where tourism is the main source of income in many municipalities [66,67]. This has led to the reactivation of handicrafts, textiles, and ceramics, as well as to the creation of high-quality local food products. The rise in rural tourism as an additional source of income or business activity has allowed many locals to continue farming on a part-time basis with the support of their families. This has enabled the survival of some farms that might otherwise have disappeared. Farming associations and cooperatives are also playing an increasingly important role, above all in the commercialization of agricultural products. This is a new, innovative practice that was almost non-existent prior to the implementation of the aforementioned European programs [68]. However, the tourism sector plays a fairly weak role in the Alta Murgia area with quite low numbers and short stays. Short-stay tourism could be viewed as beneficial in terms of sustainability and is often a typical feature of agritourism [69]. The aim should therefore be to increase the number of tourists visiting the area rather than trying to extend their stays, as this could become a new paradigm for rural development [70]. The area is characterized by a weak service infrastructure (tourist accommodation, internal soft mobility), especially for tourism that can enhance the resources of the rural landscape. Although the municipalities in this area have a strong tradition in agricultural production, excellent agri-food chains (linked to durum wheat, milk, extra virgin olive oil, and wine, internationally known) and interesting features of the rural landscape (such as typical dwellings that bear witness to the transformations that have taken place in this area), this territorial heritage is not at all valued. As expressly stated in the plan, the area's strong rural vocation has often acted as a brake on new forms of tourism when it could potentially be a positive factor in their development, linked above all to the enhancement of rural culture and customs and traditional local gastronomy. This explains why there are few high-quality local products and poor connections between agriculture and tourism, with a view to promoting multifunctionality and alternative sources of income that can supplement the income from farming.

An important rethinking of these areas is therefore required, which merges the concept of landscape with the extraordinary wealth and complexity of these rural areas. This should not be limited to the purely legislative sphere and should also recognize their cultural and identity values with greater involvement of the local communities through the activation of participation processes [71], bearing in mind that the management of natural spaces and the development of rural areas cannot be regarded as separate questions [71] and instead must be viewed as a single, common issue.

5. Conclusions

Protected natural areas in Europe today are facing very complex, highly diverse challenges, which prevent us from obtaining a generalized picture. This is due both to their progressive growth in terms of number and size and to the variety of categories and typologies that have emerged with profound regional differences. This is why in this study of two emblematic cases in Spain and Italy, an in-depth dynamic analysis was required. To this end, we applied a specific indicator (the Production Specialization Index) which was capable of detecting trends in farming specialization over time (as regards which crops were cultivated and which livestock species were reared). This indicator enabled us to identify local dynamics by making comparisons between the areas inside the parks and the belt areas surrounding them, so highlighting the relationships between the protected area, crop specialization, and the development objectives connecting farmers with the landscape and its economic potential. The application of this indicator produced interesting results, which were analyzed here in depth with the aid of additional sources, offering useful data about specific areas of the parks.

An interesting aspect that emerged in both parks was the importance of a regulatory framework at different levels (from the international level to regional and local plans). This is an essential prerequisite for the functioning of protected areas, such as natural parks, in which a series of objectives and operating rules must be established.

In both parks, the plans try to reconcile the protection of biodiversity and the landscape with the economic growth objectives of the areas concerned. This requires ever greater efforts in the management of rural resources and greater support from the different public administrations so as to enable the parks to carry out the mission assigned to them, in this way enhancing the protection and development of the surrounding territories. In both cases, the park areas are the result of internal and external forces that have played a fundamental role in the efforts to improve and promote the local resources that form part of the historical and cultural heritage of these areas. These programs are often aimed at boosting the local economy, especially by fomenting tourism, although the links between agriculture and local products remain weak.

The results obtained only partially confirm the resurgence of these rural areas. In both parks, a tendency towards extensification was observed in certain specific crops and species because they are more profitable and/or are considered to be of higher quality. In other cases, there is a risk of traditional crops and agricultural landscapes being abandoned and lost. Traditional landscapes are also threatened by the emergence of capital-intensive forms of agriculture. In both cases, greater, more effective involvement of local communities and farmers is required in the planning. In areas where the regulation of uses is less strict, traditional crops such as olive trees, vineyards, and legumes, or husbandry, such as sheep and goats, tend to be maintained.

In both parks, the conservation of natural heritage has been the priority objective through various programs and ongoing interventions. The actions aimed at promoting the multifunctionality or sustainability of agriculture, the maintenance of the agricultural heritage, and the agrobiodiversity of these areas have been less successful. Therefore, as emerged in our analysis, the various protection objectives should include the conservation of the area's agricultural heritage, as well as measures aimed at protecting the tangible and intangible values, uses, and activities that have produced and reproduced this "rural cultural" heritage over time.

The cases analyzed present various similarities in aspects such as the need for greater local participation in planning and decision-making and the need to enhance the natural and cultural heritage and strengthen the connections between territories and economic activities. The two natural areas would also benefit from a wider range of high-quality local products, which at present tend to be concentrated in a few municipalities within specific geographical areas of Protected Designation of Origin, often promoted by local consortia.

In fact, in both the Sierra Nevada and the Alta Murgia parks, there is significant potential for the further enhancement of quality products, thanks to the support and the communication role played by the parks. In this way, the quality image of these products is bolstered by their natural origin inside a protected area, and they can also benefit from the growing number of tourists. There is also potential for the enhancement of agricultural landscapes and the multifunctionality of the agroecosystem (park areas and those nearby). This means recognizing other functions, in addition to environmental protection, which improve the quality of life of the communities.

In both cases, naturbanization processes can be observed. The demographic growth in the Sierra Nevada Natural Area, which generally confirms this process, is due, in the three areas considered, to an increase in the population in a few municipalities whose demographic and economic dynamics are determined by the fact that they are part of the metropolitan area of Granada. This behavior masks the population losses recorded in most of the small, mountainous municipalities that make up these spaces. This situation is more severe in the national park than in the natural park and also affects the neighboring area. Naturbanization is more evident in the AMP, where both internal and external municipalities show general growth dynamics (with some exceptions in two smaller internal municipalities). In this case, the metropolitan area of Bari plays a strong role in this process. These findings highlight the need to investigate these processes of naturbanization of protected spaces in much greater depth.

In general, within the context of growing interest in protected areas and parks, it is essential that their economic growth objectives be closely interlinked with those of sustainable development. Farm management should be oriented towards a relational, dynamic approach to enhance the territories involved. This will require a multifunctional approach and participatory planning based on cooperation between all the different stakeholders and interested parties. This requires specific interventions at an economic, social, institutional, and regulatory level, with a more in-depth investigation of the internal dynamics behind the different management models and of the relationships between the different tiers responsible for managing regional development.

National parks, thanks to their enormous natural, cultural, agricultural, and social heritage, can act as natural laboratories for testing and evaluating policies for local, community-led, sustainable development based on the endogenous resources of the region while also becoming "living landscapes" in which a range of business activities (agriculture, tourism, handicraft, education, culture) can be carried out in a combined, integrated way.

This is especially true in the wake of the COVID-19 pandemic. In both Spain and Italy, research has shown that COVID-19 has slowed down the processes of demographic decline in the rural world and, in some cases, even reversed it [24,72,73]. This would explain the sharp increase in house purchases in rural areas [74–76]. The pandemic has also accelerated the growth of specific forms of tourism, and this has highlighted new ways in which societies are looking at rural tourism, which is increasingly diversified and seems strongly linked to human health and safety. In this way, it expresses its potential for human well-being and for the resilience of rural areas [77].

A possible line of research would be to try to assess the impact of the COVID-19 pandemic and whether new needs, strategies, and solutions have arisen for these areas. Finally, our research was centered, above all, on a quantitative methodology that combined different sources to perform an in-depth analysis to help understand and interpret the trends at a local level. However, in future developments of this research, an important step forward would be to combine these quantitative data with qualitative analysis, including the views and perceptions of local residents, park managers, entrepreneurs, and other stakeholders. Future lines of research will require constantly updated data at appropriate territorial scales in order to be able to monitor the situation and make the forecasts necessary for drawing up the area strategy. In particular, we are referring to Agrarian Censuses, the last of which were published about 10 years ago in both countries. The lack of more recent information makes it difficult to know and understand the changes that have been taking place in recent years and to assess the impact of the protection and development mechanisms being applied within the different parks.

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Territorial Analysis of the Survival of European Aid to Rural Tourism (Leader Method in SW Spain)

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Abstract: Due to the problems of the European rural environment, the European Union introduced territorial development strategies called the Leader Method (LEADER Initiatives and the now extinct PRODER Operational Programs implemented only in Spanish territory). The objective was to activate the economic development of these areas, to maintain the population and to slow down the migration and aging processes. During the last 25 years, these initiatives have been implemented in European rural areas, and more particularly in Extremadura, establishing new activities such as rural tourism, which has become the economic backbone of many families, complementing agricultural incomes. The development of rural tourism has led to the implementation of accommodation and catering services throughout Extremadura, adapting to the new tourist demands. However, after 25 years, its sustainability has been very different, with contextual variables that have conditioned its success. Therefore, it is necessary to analyze the economic sustainability of the tourism offer financed by Leader and the extinct Proder in order to identify the factors that have determined its success in a territory with very diverse characteristics. For this purpose, a methodology based on two statistical analysis techniques (principal component analysis and cluster analysis) has been designed to establish behavioral patterns through the different context variables used. The results obtained have shown that factors such as investment, location, the presence of protected resources and accessibility are determining factors for the survival of the tourism offer.

Keywords: Leader Method; rural tourism; survival of tourist infrastructures

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1. Introduction

Currently, the European Union (EU) considers 44% of its territory to be rural in character [1], understanding rural areas (1 km^2 population grid cells) to be those whose population density is (usually) less than 300 inhabitants per km^2 and/or fewer than 5000 inhabitants. In these rural areas, since the mid-20th century, a significant reduction in population has been taking place, from 47.7% of the European population in 1960 to 25.3% in 2019 [1,2], with Spain being one of the European countries with the highest percentage of rural depopulation, especially in the second half of the 20th century [3]. This loss of population has led to significant changes in the economic functions of rural areas, with a considerable decline in employment in the agricultural sector, the traditional economic base of families, and the emergence of new activities focused mainly on the service sector, such as tourism [4].

Since 1950, the EU has been advocating the development of the agricultural sector in these areas through the Community Agricultural Policy (CAP), with the aim of making the agricultural sector competitive, generating optimal incomes for farmers, and allowing the population to remain in these areas. However, although agriculture continues to be a strategically important policy sector and is the main sign of identity that determines the rural environment, most rural areas have become increasingly less dependent on agriculture [5], due to its low profitability and the incursion of other economic sectors that have complemented agricultural income. The introduction of new activities arose in the EU with a change of strategy at the end of the 20th century, when the development of rural areas was included as a policy with its own character supported by sustainable development [6,7]. Within these new rural development strategies, in 1990 the EU created the Leader Initiative, aimed at co-financing new economic activities in rural areas (tourism, creation of SMEs, rehabilitation, etc.). European governments were based on the idea of local development, combining a bottom-up local development model with a top-down development model at the European, national and local levels. That is to say, an endogenous [8] and bottom-up local development model that starts from the autochthonous population, the administrations (town hall) and the business and social fabric (associations, cooperatives etc.) at the local level that, together with the LAG, are in charge of deciding the development strategies and the projects to be co-financed. This is a top-down development model in which the national administrations (regional and national governments) and the EU (EAFRD Funds) fund and review (through evaluation systems) the development strategies and the projects implemented. This methodology was developed as a pilot initiative in 217 European territories through Local Action Groups (LAGs). These groups, or non-profit associations, are responsible for the implementation of Leader in the territories and are formed by local economic, political and social agents.

The Leader initiative ended in 1994 with such good results that in mid-1995 the European Commission (Official Journal of the European Communities (94/C 180/12) [9]) approved a new programming period, Leader II (1994–2000). This new period was created with the aim of continuing to promote the diversification of economic activities in rural areas, through innovative and cooperative actions, extending its funding to new territories. In Spain, the number of applications to participate in the new period was much higher than the funding received (of the 152 applications, 79 LAGs were selected [10]), so in 1996 the Operational Program Proder (Operational Program for the Development and Economic Diversification of Rural Areas 1996–2000) was approved at the national level for those Leader II applications that had not been eligible for funding in Spain. Proder was integrated into the Community Support Framework for structural interventions in Spanish Objective 1 regions (those European regions whose gross domestic product per capita is less than 75% of the European average) [10,11]. It involved complementary aid to the Leader Community Initiative [12], with similar objectives, except for the obligation to finance cooperation projects and to be as innovative. After the end of these two programs, Leader + and Proder II (2000–2006) (Council Regulation (EC) No. 1260/1999 of 21 June 1999, and Royal Decree No. 2/2002 of 11 January 2002 [12,13]) were initiated with the objective of continuing to make progress in increasing the potential of the territories with new, more long-term strategies. Leader + and Proder II were in force until 2006. After the end of these periods, there was a reform of the European Structural Funds, which established that LAG investments were determined by the European Agricultural Fund for Rural Development (EAFRD) regulation, which included Leader as one of its funding axes. This new period, called EAFRD, was in force from 2007 to 2013 and included the LAGs managing both the Leader initiative and the Proder Program.

The Leader Initiative and the Proder Program were based on the creation of different strategic actions to achieve their objectives. In general, these strategic measures or actions were aimed at enhancing the value of local and rural heritage, promoting training, rural tourism, the creation and maintenance of SMEs, crafts and services, as well as the revaluation of agricultural and forestry production and environmental conservation [8]. Within these measures, rural tourism became one of the activities with the greatest potential to complement the income of areas deeply affected by depopulation and the crisis of the traditional agricultural production model [14], being one of the activities with the greatest funding at the European level [15]. This initiative favored the creation and improvement of accommodation and catering services throughout the rural geography [16,17].

In Spain, tourism was one of the most heavily financed measures during the early periods of the Leader and the Proder Program. This fact was caused by the excessive overcrowding of sun and beach tourism, which motivated the search for new destinations, and by a change in the paradigms of tourists at the national level, who began to look for new forms of weekend leisure away from large urban agglomerations, but close in distance (it is estimated that 70% of tourists live less than 200 km away [18]). As a result, Spanish rural areas saw tourism as a way to activate their economies and mitigate regressive demographic processes.

Extremadura, the case study, is characterized as one of the most rural Autonomous Communities in Spain; 76.8% of its municipalities have less than 2000 inhabitants and account for only 20.8% of the regional population. In addition, its population density is 25.5 inhabitants/km^2, the second lowest in Spain, with a national average of 93 inhabitants/km^2. Between the 1960s and 1970s, Extremadura lost around 800,000 active farmers who emigrated out of the region [19,20], mainly to urban and industrial areas, in search of better jobs. This population loss began to stabilize in the early 1980s, when the 1973 economic oil crisis forced some industrial workers to return to rural areas due to a lack of job offers, since urban areas could no longer absorb the agricultural surplus. Since then, the rural areas of Extremadura have continued to lose population, although much more slowly than in the 1960s, due to high mortality rates and low birth rates. The aging and weak natural growth of the population, together with the lack of job opportunities, is conditioning the rural environment, becoming a factor of repulsion of the active and young population of the municipalities with a smaller population [21]. Due to all this, Extremadura is one of the least developed regions in the EU; its GDP is still below 75% of the European average, with an excessive dependence on an uncompetitive agricultural sector.

For all these reasons, Leader and Proder have been operating in the region from Leader I, with four LAGs, to the present, with 24 LAGs. These 24 LAGs include all the municipalities except the four urban centers: Badajoz, Cáceres, Mérida and Plasencia. One of the most developed sectors under the Leader Initiative and the Proder Program in the region has been tourism. This has allowed the creation and improvement of accommodation and catering services in areas that would not have been possible without this aid, as well as the development of projects and initiatives that have allowed the incorporation of this region into national and international tourist flows, attracting thousands of tourists every year [22].

The importance of the Leader Method, the Proder Program and tourism in rural areas is also evident in the scientific field, since there are a large number of studies that reflect this. Of note are the studies by Candela Hidalgo et al. [23], on the potential of tourism in mountain areas with reference to the number of accommodations and catering services financed under Leader, or the studies by Tirado-Ballesteros and Hernández-Hernández [24], analyzing the social and economic repercussions of investments in rural tourism in Castilla-La Mancha during Leader and Proder. It is also necessary to mention the analysis of Yubero Bernabé and García Hernández [25], on the evolution of the tourism offer financed by Leader in Aragón or the study of Morán Rodríguez and Sotelo Navalpotro [26] on the benefits of Leader + on tourism in the northern mountains of Madrid Also, in the Valencian Community, the studies by Pitarch and Arnandís [27], analyze the impact of Leader and Proder policies on the tourism sector, including an analysis of the increase in tourism offer promoted by these aids, or in Extremadura by Nieto and Cárdenas that analyze the distribution of Leader and Proder aids to tourism in Extremadura [28,29]. With reference to Proder, the studies by Castellano-Álvarez et al. [30,31], on the limitations of rural tourism as a way of diversifying the economy in mountain areas are worth mentioning.

The importance that tourism has had on Spanish rural areas is undeniable, and this has promoted the creation of a tourist offer with the intention of complementing family economies. The articles cited above are just a smaller sample of the direction taken by scientific studies based on tourism financed by Leader and Proder. However, despite the importance of investment in tourism enterprises, the studies on their long-term sustainability are limited. In this case, the study by Santos et al. [32], analyzing the survival of all businesses created in Alentejo (Portugal) during Leader+ through binary choice models. The analyses carried out by Navarro et al. [33], about the evolution of the enterprises created during Leader, differentiating by measures: Tourism, SMEs and empowerment of agricultural and endogenous production, in three local action groups in Andalucía. Finally, the study carried out by Castellano-Álvarez et al. [30], on the limitation of tourism to diversify rural economies through interviews with owners of rural lodgings, among other business. This study was carried out in a territory financed under the Proder Program.

To this end, the objective of this project was to study the evolution of tourism businesses created under Leader and the Proder Program, in one of the regions that has benefited the most from these aids: Extremadura. We use a methodology that allows determining which variables are affecting the sustainability of these businesses, and thus create a pattern of behavior that will help the implementation of future businesses.

This article is an innovation in its field of study and also allows corroborating the effectiveness of a less-developed methodology in the field of tourism and especially in studies on the degree of success of accommodations and catering businesses: cluster analysis together with principal component analysis. Cluster analysis, unlike PCA, will allow the grouping of data on the basis of the characteristics of the municipalities analyzed, taking into account 100% of the variance, so that the groups are the most homogeneous among themselves. The use of PCA together with cluster analysis provides more information than the use of either method alone [34].

2. Materials and Methods

2.1. Study Area

Extremadura is a region in Southwestern Spain bordering Portugal, with a population of just over 1 million inhabitants and an area of more than 40,000 km^2, which means that the population density is 25 inhabitants/km^2, well below the national average of 94 inhabitants/km^2. It is a predominantly rural region with a GDP below 75% of the European average, with significant demographic and economic problems. Extremadura is characterized by a series of physical, demographic and economic features that have enabled the region to benefit from rural development aid since the early 1990s. In general, the region lags slightly behind other Spanish regions, due to its peripheral location and its border with Portugal, as well as the complicated orography of part of its territory. These characteristics have conditioned the demographic and economic development of its population. This, together with its scarce industrial development caused by a late incorporation to the industrialization process, a scarce accessibility and a fast development of the service sector, have conditioned the economy of Extremadura's families. All this has caused the emigration of a population in continuous decline, except for the main centers of the region: Badajoz, Cáceres, Mérida and Plasencia.

All this has made it possible for aid programs such as Leader and Proder to have been implemented in the region for 30 years, since 1991 in four GAL: Sierra de Gata, Valle del Jerte, Alcántara and La Serena. The good results obtained meant that during Leader II the number of LAGs increased to 10, and in the first period of the Proder Program, Proder I (1995–2000), 12 more LAGs joined the program. During the following stages, the number increased to 24, 10 in the case of Leader +, so that the number of LAGs in Leader was maintained, and 14 in the Proder Program, adding two LAGs to the previous 12. For the following period, the Proder Program was extinguished and the 14 LAGs were included in EAFRD, the third financing period 2007–2013 (Figure 1). Therefore, the entire Extremadura territory, except for the four urban areas, Badajoz, Cáceres, Mérida and Plasencia, was included in this aid. In these LAGs, tourism has been implemented as an activity capable of complementing agricultural income and slowing down or mitigating regressive demographic processes.

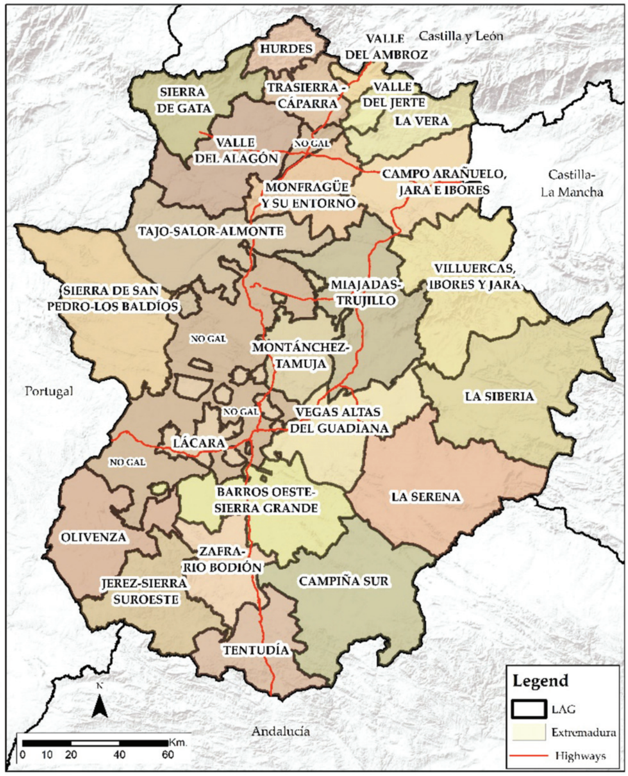

Figure 1. Local Action Groups.

2.2. Database

The first methodological step of this project was to collect all data related to the Leader Initiative, from Leader II (1995–2000) to EAFRD (2007–2013), and the Proder Program, Proder I (1995–2000) and Proder II (2000–2006). Neither the last funding period, Leader 2014/2020, has been included, as it has not been finalized, nor Leader I, as it is considered a pilot experience. These data, obtained from the Junta de Extremadura, were added to an Excel file and then georeferenced with ArcGis software. For this purpose, the postal address of each of the projects was used together with the Iberpix viewer, which allows obtaining coordinates and adding this information to the original data. Once the different layers were created in point format in ArcGis, one for each period, a homogenization of the projects was carried out based on the financed measure. For this purpose, the homogenization developed by authors Nieto and Gurría [35], was used, which classifies projects into seven different actions: Action 1, encompasses projects that finance LAG management costs; Action 2, financing in training and employment; Action 3, projects related to tourism; Action 4, intended to finance projects in SMEs, crafts and services; Action 5 and Action 6, valorization of agricultural and forestry production as well as the conservation and improvement of heritage and the environment; and finally Action 7, cooperation. In addition to the type of measure, the volume of investment was added, and within this, the volume of private investment.

Then, projects intended to finance the management costs of the LAGs themselves were eliminated, as well as the projects that made up the cooperation and professional training measures because they were not related to tourism businesses. The rest of the projects were analyzed one by one to check if they financed any type of accommodation or catering business. Therefore, projects that had financed SMEs that were tourism infrastructure or projects within the agricultural valorization measure that created new accommodation or catering services and that had been related to a farm were also reviewed. In total, more than 1000 projects, of the more than 8000 initial projects, financed some type of accommodation and catering services business. These 1000 projects were also classified into the different types of tourism infrastructure in accordance with regional tourism laws in order to obtain greater homogenization in their treatment. The classification was as follows:

– Hotel Accommodations: include accommodations classified as hotels, hostels, hotel-apartments, guesthouses and inns.
– Rural Accommodations: rural houses, rural hotels and rural apartments.
– Non-hotel Accommodations: hostels, camping sites and tourist apartments.
– Catering Service: cafeterias, pubs and restaurants.

The next step was to check whether they were in operation. To do this, we first checked if they were still active in the tourism infrastructure database, provided by the Junta de Extremadura, which shows the companies that are currently active in the region. In cases where the business did not appear in the database, it was complemented with another database called SABI (the SABI database was developed by the company Bureau van Dijk as a web tool with information on Spanish and Portuguese companies. It was designed as a tool for financial analysis and strategic marketing with information on company balance sheets, global positioning in the markets) and, finally, through field work with Internet searches and consultations with Local Action Groups.

In order to be able to compare the data with other context variables and at a detailed scale of analysis, it was decided to use the municipal scale for this work. Therefore, these projects were grouped by municipalities and both the investments, the number of projects and the survival rate (total active projects or investments) per inhabitant were standardized in order to be able to make comparisons between different municipalities without skewing the results by population size.

In summary, the variables related to public aid were as follows: investment per inhabitant, percentage of active projects, percentage of active investment, percentage of active private investment, percentage of active non-hotel accommodations, percentage of active hotel accommodations, percentage of active catering services, percentage of active rural accommodations and percentage of active places.

Once this first database was completed, a second database was created with the context variables that may be favoring or conditioning the maintenance over time of Leader and Proder investments. Physical, demographic and economic variables defining the characteristics of Extremadura's territorial structures were added, based on the variables applied in previous studies on the region [35]. The aim is to check whether the survival rate of investments is related to population growth, aging, wealth or unemployment data by sector of activity. In addition to these variables, other variables included were the minimum access time to the nearest highway per municipality, the minimum access time to Madrid and the percentage of cultural and natural resources, museums and interpretation centers in each municipality compared to the regional total. Including access time and the region's natural and heritage resources will help determine whether a favorable location, as well as the existence of resources, is positively affecting business. Access to Madrid [22] has been added as it is the main issuer of rural tourism travelers. In this way, the database was configured in 21 variables, 11 of which refer to context variables (Table 1).

Table 1. Context variables.

Typologies	Variables	Data Source
Physical	Altitude	National Institute of Statistics
Demographics	Population growth 1995–2000 Population growth 2015–2019 Old Age Index 2019	National Institute of Statistics National Institute of Statistics National Institute of Statistics
Economic	Income per capita 2019 Unemployment in the Agricultural Sector as a % of total job seekers Unemployment in the Service Sector as a % of total job seekers	Socioeconomic Atlas Junta de Extremadura State Public Employment Service (SEPE) State Public Employment Service (SEPE)
Accessibility	Minimum Access Time to highways Minimum Access Time from Madrid	National Geographic Institute National Geographic Institute
Tourism Resources	Historical and Artistic Heritage Natural Heritage Museums and Interpretation Centers	Junta de Extremadura Junta de Extremadura Junta de Extremadura

2.3. Minimun Access Time

The minimum access time will make it possible to calculate the accessibility from the municipalities to the nearest highway, as well as their access from Madrid (the main source of tourists). The study of accessibility is based on graph theory [36,37]. The graphs are a collection of nodes (the municipalities), which are connected by edges (the roads of the region), allowing us to know to which node each of the edges is connected, and to calculate the access time of each node to each edge, independent of the shape of the edges and the position of the nodes. The first step was to calculate the centroid of the municipalities, since the wide extension of the municipalities of the nuclei of the region could affect the calculation of the minimum time. Once the centroid was located, a hierarchical analysis of the edges was performed. This analysis, based on impedance, will make it possible to simulate the resistance effect associated with travel on the network [38]. For this work, the impedance has been calculated taking into account the length (in m) and the speed of the tracks (the maximum allowed: 120 km in the case of Spain), in the following expression (1):

$$[\text{length}/(\text{velocity} \times 1000/60)] \tag{1}$$

The calculation of the minimum access time from each locality to its nearest resource will show an ideal model, calculating the minimum access time from Madrid and the minimum access time to the nearest highway. The expression is as follows (2):

$$TAMi = \min\left(IR_{ij}\right)\forall j \tag{2}$$

where the minimum time from each node *i* (centroid of the municipality or Madrid) to the nearest freeway or nucleus (node *j*) is ascertained. For this purpose, we have used as a basis the cartography of the Spanish road network, data obtained from the National Download Center of the National Geographic Institute (IGN).

2.4. Principal Component Analysis

PCA is one of the most widely used multivariate analysis techniques, since it allows synthesizing or reducing the information of interrelated variables [16,39]. It is an explanatory method of variables involving external factors [40], which makes it possible to identify the latent dimensions of a set of variables and reduce them to a smaller number of independent factors, which are ordered by their explanatory power [41]. It is a technique with which new sets of variables, the principal components, are obtained as a result of the combination of interrelated variables [7]. These components represent homogeneous behaviors in different entities or elements that allow the identification of territorial substructures, since the PCA also represents the pattern of similarity of the observed inter-correlated variables [42]. Thus, the objective is to extract a reduced set of variables of m components, or underlying factors that explain most of the variance from a set of p variables [41]. It is a technique introduced by Pearson in 1901 [43], although it was later adapted to factor analysis by Hotelling in 1933 [44].

In this project, it was decided to use principal component analysis to obtain a territorial model of Extremadura that represents how the demographic and economic substructures of the region have influenced the tourist offer. By selecting this multivariate analysis, it will be possible to explain the relationships between the variables selected as representative of the regional reality.

The underlying factors are obtained through the correlation between the variables and are calculated as a weighted sum of those variables. Factor i would be (3):

$$F_i = W_{i1}X_1 + W_{i2}X_2 + \ldots + W_{ip}X_p. \tag{3}$$

As mentioned above, this type of analysis is very widespread and its application in social and human sciences [45–47] is suitable for studying complex structures, due to the reduction of a large amount of information. Moreover, it is an analysis that has already been used to study the behavior of these public aids [6], so its suitability is assured.

It should be taken into account that in order to perform the PCA it is necessary that the variables are presented in unbiased form, as rates or percentages. In addition, prospective analyses must be carried out until a matrix called the initial matrix, which is considered optimal for the study, is reached. In this way, those variables considered to be explanatory in the set or that implied collinearities for the model were eliminated. To verify the selected model, two control tests were performed: Bartlett's test of sphericity and the Kaiser–Meyer–Olkin test (KMO). The first ensures that the correlation matrix is not an identity matrix, while the second is a measure of the adequacy of the correlation matrix to perform factor analysis, so that the closer the KMO score is 1, the higher the adequacy of the matrix. The KMO is expressed as (4):

$$KMO = \sum i + j\ r\ 2\ ij \sum i + j\ r\ 2\ ij + \sum i + j\ r\ 2\ ij.m \tag{4}$$

The KMO statistic varies between 0 and 1, so it is considered that if the result is ≥ 0.75 the chosen variables are good, if it is ≥ 0.5 the idea is acceptable and if the result obtained is <0.5 it is unacceptable [48,49]. In the case of this project, the result for KMO is 0.68 so it is considered that performing the PCA with the selected variables is acceptable.

2.5. Clustering Analysis

Cluster analysis is the generic name for a multivariate procedure that groups similar objects into categories to identify (1) outliers and (2) the basic structure of the data set [50]. Cluster analysis allows grouping the data according to the characteristics of the municipalities analyzed, taking into account 100% of the variance, so that the groups are the most homogeneous among themselves. Cluster analysis presents two main types of cluster: non-hierarchical, which are called K-means, and hierarchical. In the case of this study, it was decided to use the K-means model since this model performs a classification into multiple groups, so that the total variation of the cluster is minimal. On the other hand, the hierarchical model performs a classification with a dependency structure starting from as many groups as individuals are studied [51].

As indicated, clustering was performed following the K-means algorithm. In K-means clustering, a method without spatial assignment, i.e., without spatial restrictions, was used for the participation entities. This ensures that the data are grouped according to the variables and without the influence of neighboring data, as would be the case if other grouping methods with spatio-temporal restrictions were selected. Each group will be defined through entities called "seeds". A weighting that favors selection (K++ mean values) is applied to these randomly selected seeds. The variables used were the factor scores obtained in the PCA, complying with the condition of non-correlation between variables required by cluster analysis.

The main problem of this type of analysis is to decide the number of groups, since the grouping methods are sensitive to small changes. To test the reliability of the clusters, authors such as Smith et al. [34], set up the repetition of the analyses in different clusters and choose the best solution. In this work, different cluster values were selected until it was determined that obtaining five groups was optimal. These five groups allowed minimizing the number of clusters with negligible volumes of municipalities, while, at the same time, offering a reasonable number of clusters composed of a significant number of administrative units (municipalities). The advantage of cluster analysis is that its groupings consider all the variance in the data set, as compared to the variance typically represented by the first components of a PCA [52]. Once the territorial structures were determined, it was decided to locate homogeneous spatial behaviors with cluster analysis. The use of PCA together with cluster analysis provides more information than using either method alone [34].

3. Results

3.1. General Data

In total, more than 8000 projects were studied, of which 1049 were earmarked for the financing of accommodations and catering services. Leader financed 480 projects, in which a total of 41 million euros was invested, 65% of which came from private investment. In contrast, the Proder Program finances 18% more projects, reaching 569 with an investment of more than 57 million euros, with private investment being similar to that of Leader, 64.5%. In both cases, it can be determined how private investment has been fundamental for their operation and how the local population has been involved both with these aids and with their territory.

Comparing the data between LAGs, it is possible to establish the existence of a pattern already detected for the groups belonging to the Leader Method in a previous study [15]. This study classified the LAGs into three different groups according to their financing and territorial location. On the one hand, it established a group composed of three LAGs that invested more than 5 million euros in aid. These three groups were located in the north of the region and in the border area with Portugal, located mainly in mountainous areas, although with some areas of peneplain and irrigated land. They had a great wealth of natural resources (Sierra de Gata) and a scarce business fabric with very small municipalities, where Leader investments had been oriented towards tourism in order to enhance the value of this landscape wealth. In the same category, the other two LAGs benefited from tourism due to their proximity to the provincial capital, Cáceres. Another group, with an investment of between 4 and 5 million euros, comprised three LAGs, two of them in the south of the province of Badajoz and another in mountainous areas in the north of the province of Cáceres (Valle del Jerte with nature-related tourism, and the other two, Olivenza and Tentudía, with heritage and gastronomic tourism, also benefiting from their proximity to the main city of Extremadura or to Andalusia). The last category is constituted by four LAGs, with an investment of between 2 and 3 million euros. They are located in peneplain areas with low natural mountain resources (Campo Arañuelo, Miajadas-Trujillo and La Serena), with less influence of tourism in their economic income due to a greater relevance of the agricultural sector and a small agro-industry.

This trend is similar in the case of the municipalities that participate in the Proder Program (Table 2). The first group is integrated by four mountain LAGs with an investment of more than 5 million euros. Three of them are located in the province of Cáceres and the fourth in a mixed LAG, since it integrates municipalities from both provinces. These are mountain areas, with great natural wealth related to these landscapes and the exploitation of water as a leisure resource (rivers, gorges for bathing and routes of great value for tourists). They are also areas with small populations and business fabric that have opted for investment in tourism as a way of reversing regressive demographic trends in an attempt to fix the population. As can be seen, the municipalities in the north of the region have invested in tourism as a form of economic development. The next group, with an investment of 4 million euros, is formed by three very different LAGs. On the one hand, the Valle del Ambroz, one of the LAGs with the smallest population and with an economic base linked to tourism and forestry exploitation, presents tourism resources related to nature tourism. On the other hand, the LAG Zafra-Río Bodión, composed of several municipalities that act as regional head, its economic base is linked to trade, the existence of a small industry and tourism with heritage resources, demographically it is one of the most dynamic areas of the region. Finally, the GAL Sierra Grande-Tierra de Barros has an economy linked to the agricultural sector and a small industry that favors population growth. It is the group that has received the largest volume of all the LAGs in Extremadura and, therefore, its overall figures are also relatively high in tourism when compared to other LAGs with fewer resources, although in percentage terms most of its investments have been in the revaluation of agricultural production and agro-industry. The last group is organized into seven LAGs, which, as in Leader, stand out for being located in peneplain areas with an economic base linked to agriculture and small agro-industry, especially in the Vegas Altas del Guadiana LAG, which have invested in actions aimed at agroforestry improvements. The only exception is the Monfragüe LAG, which has important figures of natural protection and lower investments in tourism. It should be noted that this LAG was created in the last Proder period, in the year 2000, and because it only manages one period, its total investment volume in tourism with respect to the total is lower, but it is very significant with respect to its total investment.

Table 2. Projects and investment in tourism.

LAGs Leader	Investment in Tourism	% Private Investment	Projects	LAGs Proder	Investment in Tourism	% Private Investment	Projects
Campiña Sur	3,118,315	61.8	34	Cáparra	2,905,954	68.1	31
Campo Arañuelo	2,464,825	65.5	22	Hurdes	5,178,228	58.2	51
Miajadas-Trujillo	3,484,672	68.7	44	Jerez-Sierra Suroeste	2,879,511	62.4	23
Olivenza	4,393,019	64.2	30	Lácara	2,161,322	69.2	27
Serena, La	2,825,715	57.7	38	Monfragüe	2,750,532	67.7	19
Sierra de Gata	5,220,789	65.2	99	Móntanchez-Tamuja	3,732,989	65.3	38
Tajo-Salor-Almonte	5,199,020	72.2	53	Siberia, La	3,443,762	64.6	32
Tentudía	4,924,447	66.6	39	Sierra de San Pedro-Los Baldíos	6,231,382	64.9	76
Valle del Alagón	5,017,349	60.0	45	Sierra Grande-Tierra de Barros	4,336,448	67.0	39
Valle del Jerte	4,563,585	64.8	76	Valle del Ambroz	4,976,198	63.7	53
				Vegas Altas del Guadiana	769,676	63.9	8
				Vera, La	7,722,711	61.2	74
				Villuercas-Ibores-Jara	5,898,528	62.5	67
				Zafra-Río Bodion	4,868,517	71.5	31
Total	41,211,740	65.0	480	Total	57,855,758	64.5	569

3.2. Principal Component Analysis

Once this first descriptive analysis of the general data has been established, the results obtained from the analyses performed will be presented. First, the results of the statistical analyses of the variables used in the study are shown. The number of elements is 265, which means that of the 384 municipalities that make up the LAGs in the region, 69.1% are municipalities that have invested in tourism businesses. By variables, demographic variables such as old age index and population growth, social variables such as unemployment data, as well as the percentage of tourism resources are the most stable variables, with a standard deviation close to their mean (Table 3). The demographic variables reflect the current situation of the region, characterized by a slight but constant loss of population over the last three decades and related to negative vegetative growth (higher mortality rates compared to lower birth rates) rather than migratory movements. In these last decades of the 20th century and the beginning of the 21st century, the massive migratory movements of previous decades in Extremadura (the so-called rural exodus) no longer took place. Thus, the population is maintained with slight deviations in relation to the economic trends of the time. This is reflected in the high rate of old age, 28.6 inhabitants over 65 years of age, with a low standard deviation that shows that the trend is inherent to the entire region. The socioeconomic variables, income and unemployment, show that the weight of agriculture is still evident in the region's economy, due to the high unemployment in the agricultural sector and that the economic income is not very high (an average of 10,273 euros per inhabitant and a deviation of 1285). The region's economy went from an agricultural subsistence economy to one based on the service sector, with a strong presence of the public sector, without going through an industrial revolution. The tertiary sector in Extremadura is also characterized by a high specialization in tourism with high unemployment rates due to the seasonality of the sector. As for the percentage of tourist resources, the region has almost 30% of its territory protected by natural resources (Nature network, United Nations Educational, Scientific and Cultural Organization-UNESCO) and more than 200 heritage resources that have been linked to tourism (with a high percentage also of protected Cultural Interest Assets of the Junta de Extremadura or at the international level by UNESCO). Road access is essential in the region, since rail lines are scarce and slow and there is only one airport with flights only to Madrid and Barcelona (in summer it extends its flights to the Canary Islands and the Balearic Islands) [53,54]. The region is structured by two state highways that run from north to south and from northeast to west, connecting the region with Madrid and Lisbon. However, a significant part of the region's municipalities present accessibility problems [55]; the average access time to the highways is 20 min, with a deviation of 15.8 min with respect to the average. If we look at the data relating to the country's capital, we can see that the average is 3 h.

Table 3. Statistical analyses.

Variables	Average	Standard Deviation	Number
Altitude	474.26	162.55	265
Population growth 1995–2000	−3.28	10.65	265
Population growth 2015–2019	−5.35	4.52	265
Old Age Index 2019	28.70	7.70	265
Income per capita 2019	10,273.67	1285.80	265
Unemployment Agricultural Sector	11.57	8.84	265
Unemployment Service Sector	69.23	12.17	265
% Tourism Resources	0.28	0.24	265
Access Madrid	200.08	55.06	265
Highway Access	19.41	15.85	265
Active projects	60.8	37.35	265
Active Investment	62.60	39.76	265
% Active Private Investment	61.44	40.60	265
Investment per inhabitant	459.28	780.12	265
Percentage of Active Hotel Accommodations	16.67	36.65	265
Percentage of Active Non-hotel Accommodation	18.81	38.16	265
Percentage of Active Catering Services	27.93	41.20	265
Percentage of Active Rural Accommodation	47.65	44.31	265
Percentage of active places	58.00	47.88	265

Regarding the specific variables of Leader and Proder management, it should be noted that the average investment per inhabitant is 459 euros, with a wide standard deviation of 780 euros. Thus, it is possible to determine the existence of concentrations in some municipalities with respect to others. The percentages of active projects, active investment and active private investment show an average of 60%, with a deviation (approximately 40%) that indicates a high dispersion of the data. Finally, the descriptive statistics show that the variables referring to accommodations and catering services also show differences. The average for active rural accommodation is close to 50%, this is followed by catering services (27.9%), extra-hotel accommodation (18%), and hotel accommodation (16.6%). In all cases, they present very wide deviations so that we are going to find very different realities depending on the territories and, with the later analyses, we will be able to locate them spatially, since not all the municipalities have had investment in all the typologies.

The next step was to check the explanation of the variables through the communalities (Table 4). The principal component analysis will allow us to obtain an explanation of each of the variables through the communalities, this value expresses the part of each variable (i.e., its variability) that can be explained by the factors common to all of them. To obtain this factor, the squares of the correlations or factor loadings retained with the variable are added [6], thus expressing the proportion of variance of the variables extracted with m factors, where m is the number of factors retained. If m is equal to the total number of variables, the communality is 1. In the case of this study, almost all the variables present values higher than 0.6 (only the variables referring to population growth between 1995 and 2000, altitude and investment per inhabitant, with an extraction of 0.46, 0.55 and 50 respectively), which shows the high explanation of the set. The variables that explain the most are those that refer to the aid itself (investment, projects, active supply and active investment) as well as the variables referring to job seekers and the percentage of tourist resources. The variable with the least explanation is the population growth variable. This variable is less explained, since it is more complex, as most of the rural municipalities in Extremadura have lost population in recent decades.

Table 4. Communalities.

Variables	Initial	Extraction
Altitude	1	0.55
Population growth 1995–2000	1	0.46
Population growth 2015–2019	1	0.66
Old Age Index 2019	1	0.68
Income per capita 2019	1	0.66
Unemployment Agricultural Sector	1	0.75
Unemployment Service Sector	1	0.80
% Tourism Resources	1	0.72
Access Madrid	1	0.69
Highway Access	1	0.67
Active projects	1	0.89
Active Investment	1	0.93
% Active Private Investment	1	0.91
Investment per inhabitant	1	0.50
Percentage of Active Hotel Accommodation	1	0.56
Percentage of Active Non-hotel Accommodation	1	0.70
Percentage of Active Catering Services	1	0.70
Percentage of Active Rural Accommodation	1	0.75
Percentage of active places	1	0.73

The results obtained (Figure 2 and Table 5) show that of the 20 components extracted in the analysis, only seven have eigenvalues above 1, so the rest of the components had to be eliminated. This is based on the assumption of Chatfield and Collin [48], who stated that components with an eigenvalue less than 1 should be eliminated, since they explain a very small part of the variability [56]. In this way, the first seven extracted components were rotated according to varimax rotation in order to facilitate the interpretation of the extracted components [49]. As a result, the percentages of the total variances of the seven extracted components represent more than 70% of the total variance of the observed variables, i.e., the seven extracted components explain the variables analyzed. However, although these seven components have an initial eigenvalue of more than 1, only the first five will be used in the cluster analysis. This choice was determined after analyzing the scree plot, since it is considered that those components in which the trend line breaks should not be taken into account, since their explanation in the set is low [50]. In the case of this study, the line begins to break in component 5, so as already indicated, they were considered optimal for the cluster analysis.

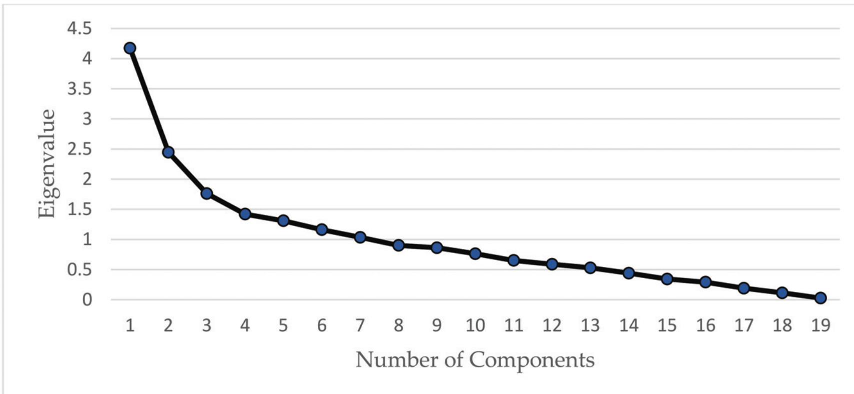

Figure 2. Scree plot.

Table 5. Factor weights of the variables.

Variables	Component 1	Component 2	Component 3	Component 4	Component 5
Altitude	0.17	−0.27	−0.32	**0.37**	0.04
Population growth 1995–2000	−0.14	0.21	0.39	**−0.25**	0.08
Population growth 2015–2019	**−0.18**	**0.46**	0.35	−0.01	0.11
Old Age Index 2019	0.28	**−0.73**	−0.20	−0.14	0.11
Income per capita 2019	0.21	**−0.55**	0.36	−0.04	**0.39**
Unemployment Agricultural Sector	**−0.26**	**0.43**	**−0.59**	**−0.26**	0.26
Unemployment Service Sector	0.19	**−0.32**	**0.62**	0.19	**−0.38**
% Tourism Resources	0.16	0.02	0.19	**0.67**	**0.41**
Access Madrid	**−0.27**	0.38	−0.12	0.20	**−0.62**
Highway Access	0.09	−0.15	−0.41	**0.55**	**−0.32**
Active projects	**0.86**	**0.33**	0.07	−0.13	−0.07
Active Investment	**0.90**	**0.29**	0.05	−0.13	−0.09
% Active Private Investment	**0.89**	**0.28**	−0.03	−0.13	−0.09
Investment per inhabitant	0.33	**−0.54**	0.04	−0.10	−0.01
Percentage of Active Hotel Accommodation	0.18	**0.31**	−0.10	**0.38**	**0.40**
Percentage of Active Non-hotel Accommodation	0.16	0.24	0.15	0.15	0.18
Percentage of Active Catering Services	0.23	**0.34**	0.32	−0.09	−0.19
Percentage of Active Rural Accommodation	**0.80**	−0.05	−0.22	−0.13	0.01
Percentage of active places	**0.75**	0.02	−0.28	0.06	0.11

Table 5 shows the coefficients of the rotation matrix of the five components. From these coefficients, their higher or lower values and their sign, positive or negative, it will be possible to determine which are the variables that define each of the components. Component 1 (C1) is characterized by interrelating investment and active supply with the rest of the variables. This allows the differentiation between those areas with a higher percentage of success and those whose success has been moderate, low or non-existent (some municipalities with investment in tourism supply have presented percentages of active). Its positive substructure is formed with the highest significances. These are: supply and active investment, rural accommodations, active vacancies, private investment and the number of vacancies created (variables with the highest degree of explanation, all above 0.7). Also, to a lesser extent, of investment per inhabitant, the old age index, the percentage of active catering services and income per inhabitant (with a factorial weight of between 0.33 and 0.20). In a third group, below 0.20, we find the variables of unemployment in the service sector, the percentage of tourist resources, altitude, the percentages of hotel and non-hotel accommodations, and finally access to highways. On the contrary, in the negative substructure, the variables of access time to Madrid, agricultural unemployment and growth 2015–2019 appear correlated, although with not very high factorial weights. This cluster explains the degree of success of the tourist offer, which is why it has been defined with this denomination.

Component 2 is determined by the negative substructure. The old age index, income, investment per capita and unemployment in the service sector determine this component, which has been named as aging areas that have received significant investments and have average incomes. In the positive substructure, population growth from 2015 to 2019, supply, active investment and also with the active private participation and the percentage of active hotels, catering services stand out with a weight of less than 0.46.

As opposed to the two previous components, Component 3 is very clearly defined by the dichotomy between agricultural unemployment and unemployment in the service sector. In the positive substructure, the variable reflecting unemployment in the service sector stands out with a factorial weight of more than 0.6, and in the opposite case, with a factorial weight of −0.59, the variable reflecting agricultural unemployment in the region. For this reason, this component has been referred to simply as job seekers by sector. Component 4 is determined by the variable reflecting the percentage of tourist resources, with a factorial weight of more than 0.67, followed by access to highways, the percentage of active hotels and altitude with a factorial weight of 0.55, 0.38 and 0.37 respectively. They will be located in mountain areas with high protected resources and proximity to highways. In the case of the negative substructure, population growth from 1995 to 2000 and agricultural unemployment stand out with a factorial weight of less than 0.3. In the case of this component, it was called tourism resources. Finally, Component 5, known as the influence of Madrid, is characterized in the negative substructure by access to Madrid with a weight of −0.62 and in second place the variables that explain unemployment in the service sector, access to highways, in the case of the positive substructure, with a weight of less than −0.4, is defined by the active projects in hotels, by the percentage of tourist resources and by the income per inhabitant. However, this last factor needs very little explanation because of its complexity in the relationships between variables.

3.3. Cluster Analysis

Once this overview has been established, the results obtained in the cluster analysis will be explained. One of the advantages of the cluster analysis, in relation to the PCA, is that it allows spatial groupings of the results to be located, thus complementing the information obtained by the PCA. For this analysis, the factorial weight of the Extremadura municipalities in the five extracted components were taken into account. After different control tests, the selection of five clusters was considered to be the optimal option. This option made it possible to minimize the information by offering a reasonable or a representative number of administrative units (municipalities) in each of the clusters. In summary, the objective was not to obtain clusters with very small volumes of municipalities, and at the same time, very few clusters with heterogeneous values. In each of these five groups, there is a concentration of municipalities (clusters) with similar characteristics in terms of the sustainability parameters of the investments and of the context variables analyzed that will allow a pattern to be established (see Table 6 and Figure 3).

Table 6. Average component values by group.

Variables	Group 1	Group 2	Group 3	Group 4	Group 5
Component 1	0.74	−1.23	−1.24	0.17	0.65
Component 2	−0.51	0.42	−0.52	0.09	0.59
Component 3	−0.23	−0.55	0.74	−0.31	0.60
Component 4	0.60	−0.20	0.10	0.29	−0.62
Component 5	−0.60	−0.46	−0.20	1.54	−0.09
N° of Municipalities	75	44	38	50	58
Success rate	High	Low	Low	High	High
Active projects	82.6	19.8	15.1	76.1	79.7
Active Investment	86.1	12.5	13.2	79.1	87.6

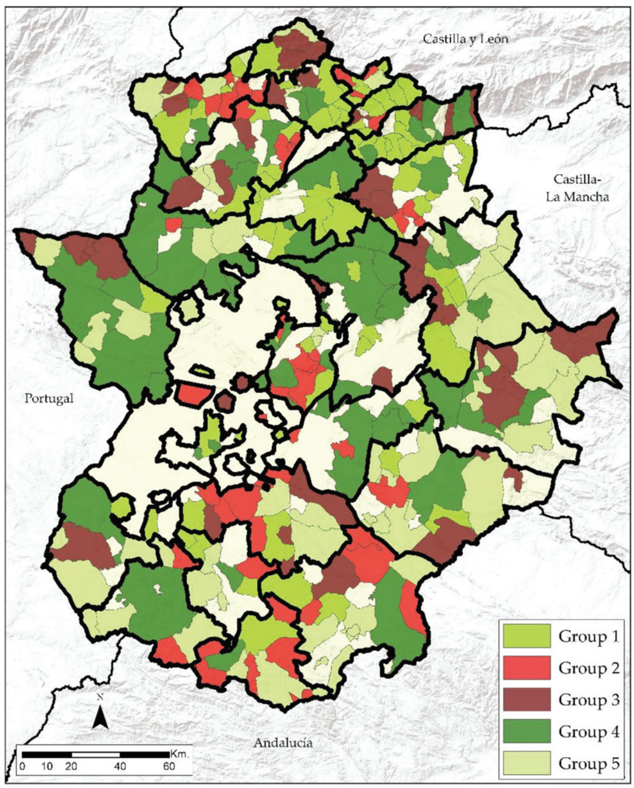

Figure 3. Cluster analysis.

Group 1: group composed of 75 municipalities with an average population of 1399 inhabitants located mainly in the mountainous areas in the north of the region (Table 7). It presents a positive average in the values of Components 1 and 4, which represent the rate of success of the tourist offer and the tourist resources of the region, respectively (Table 6). While in those corresponding to Components 2, 3 and 5 they are negative, representing aging, the agricultural-services sector dichotomy and the influence of Madrid, respectively, which can be explained by the internal characteristics of the group (Table 6). This is a group that has been experiencing a sustained loss of population, around 4%, both at the beginning of this aid and at present, and therefore the negative values of Component 2. The old age index is high, 29.3, and the average income is very similar to that of the rest of the groups (there is no great variability in the average income in the different groups.

In Extremadura, the average income does not show large differences between municipal values, unlike what happens in other Spanish regions, varying from the municipalities with the lowest wealth at 9000 euros to those with the highest income at 15,000 euros). It is a group with an economy dependent on the monoculture agricultural sector and with a high seasonality in the north, as is the case of the cherry in the Valle del Jerte or the cultivation of tobacco in La Vera and in irrigated areas also located in the north. Its negative values in Component 3 are due to the seasonality of the agricultural sector, especially in the Valle del Jerte area, where the concentration of the harvesting season in a few months of the year increases unemployment in the agricultural sector. These are the territories where tourism activity has been most developed with Leader (they have high values in Component 1 where the highest investments in tourism per inhabitant appear). This is mainly due to the existence of highly valued natural resources of high environmental conservation related to the mountains and water resources (rivers, gorges and streams adapted for bathing). These resources have allowed the development of leisure and entertainment offers, benefiting the creation of tourist accommodations in the surrounding area, which is reflected in the positive values of Component 4. Many of them have also benefited from their proximity to Madrid (the main source of tourists to Extremadura), as well as to the main highways in the region. As mentioned, it is a group where the investment per inhabitant is the second highest, only surpassed by group 5, with 555 euros per inhabitant (Table 7). It is also one of the most successful because it has an average active investment of more than 85%, as well as the percentage of projects above 80%. It is a group that has made its investment mainly in rural type accommodation and 90% of the accommodation places created are still active.

Table 7. Average data by group.

Variables	Group 1	Group 2	Group 3	Group 4	Group 5
N° of Municipalities	75	44	38	50	58
Average population	1399	2385	864	5129	1728
Altitude	486	483	475	430	500
Population growth 1995–2000	−3.98	2.15	−5.7	−3.53	−4.66
Population growth 2015–2019	−4.18	−3.10	−7.7	−4.95	−6.55
Old Age Index 2019	29.3	26.6	30.9	25.5	30.6
Income per capita 2019	10348	10111	10475	10492	9978
Unemployment Agricultural Sector	14.6	8.8	16.3	10.0	7.7
Unemployment Service Sector	64.4	72.0	62.5	70.6	76.3
% Tourism Resources	0.2	0.1	0.2	0.4	0.2
Access Madrid	176.1	215.5	207.1	188	224
Highway Access	13.0	13.5	27.4	15.0	30.5
Active projects	82.6	19.8	15.1	76.9	79.7
Active Investment	86.1	12.5	13.2	79.1	87.6
% Active Private Investment	85.1	9.2	13.0	81.1	85.0
Investment per inhabitant	555	243	485	202	702
Percentage of Active Hotel Accommodation	25.3	7.3	5.2	22.5	14.9
Percentage of Active Non-hotel Accommodation	19.3	14.7	12.2	16.3	27.5
Percentage of Active Catering Services	6.2	7.5	6.5	86.4	34.9
Percentage of Active Rural Accommodation	78.3	6.7	12.4	33.9	73.7
Percentage of active places	90.8	15.7	18.9	38.8	89.6
Success rate	High	Low	Low	High	High

Group 2: this group is composed of 44 municipalities, with an average population of 2385 inhabitants (Table 7). In the case of this group, it presents a positive average only in Component 2, which reflects the fact that they are municipalities with a lower population loss, and negative values in Components 1, 3, 4 and 5 (Table 6). This group is characterized by being the only one that gained population at the beginning of the Leader initiative and the Proder Program, although for the period 2015–2019 it lost 3% of its population. It presents the second lowest old age index (26.6) only below group 4. Economically, there are two tendencies: on the one hand, those municipalities with a larger population with an

economy related to the productive irrigated and rainfed agricultural sector, with special relevance to the use of grapes and olives, which is also joined by a small agro-industry. On the other hand, municipalities that stand out for an economy are based on the use of natural resources for electricity production, such as hydroelectric or nuclear power plants. The first subcategory is also characterized by municipalities that act as county seats, with a greater development of the service sector with strong links to the public sector. On the other hand, municipalities stand out for an economy based on the use of natural resources for electricity production, such as hydroelectric or nuclear power plants. The first subcategory is also characterized by municipalities that act as county seats, with a greater development of the service sector with strong links to the public sector. It is the group with the lowest percentage of natural and cultural resources, one of the groups that, on average, is farthest from Madrid, more than 3 h and 30 min away, and located in areas of peneplain or irrigated plains. Territories that do not have the natural wealth of the mountain areas, nor the wealth of heritage or services to the cities of Extremadura. It is the group that presented lower investments in Leader and Proder tourism together with group 4, with 243 euros per inhabitant, because its investments have been related to the development of agricultural activities, SMEs and services to its population. As reflected by the value of Component 1, it is the group with the lowest supply and investment (20% and 12% respectively, Table 7). Only non-hotel accommodation exceeds 10% of the assets, linked to the pilgrimage of the Camino de Santiago. These results explain the values of the components, especially in the case of component 1, which shows how the degree of success in this group is low.

Group 3: this is composed of 38 municipalities with an average population of 864 inhabitants (Table 7), with positive values on Components 3 and 4, and negative values in Components 1, 2 and 5 (Table 6). Most of them are small municipalities, the municipality with the largest population has less than 4000 inhabitants. In general, they are municipalities that have lost a significant percentage of their population, reaching 7% in the period 2015–2019, which explains the values of Component 2. It is the most aged, with an economy mainly linked to the agricultural sector, the irrigated area of the northwest of the region. There are few municipalities, which due to their small population and aging do not have enough business fabric to invest in the tourism sector, nor in Leader and Proder in general. Although they are close to areas with natural or cultural wealth, they have positive values in Component 4, but being far from Madrid and from the main highways and being surrounded by more dynamic municipalities, with a larger population and a better tourist offer, their tourist offer has not survived, reflected in the negative values of Component 1. They present an average investment of 485 euros per inhabitant, a low survival rate of both projects and investment (15.1 and 13.2, Table 7) and also of active private participation (13%). Among the offer they designed they also present very low indicators, with all of them with less than 15% active (hotel, for example, only 5% are maintained and rural, which are the most successful within this territory, only 12.4% remain active).

Group 4: this group is composed of 50 municipalities with an average population of more than 5000 inhabitants (Table 7). It presents positive average values 1,2,4 and 5, and negative in Component 3, due to higher average unemployment in the service sector (Table 6). Most of these municipalities are located in the Extremadura peneplain. With respect to population, this group is currently losing 5% of its population, but it is the least aged group of the 5. This group is characterized for being the one with the highest percentage of tourist resources, related to historical-artistic resources, also taking advantage of its proximity to cities such as Cáceres or Mérida (these two cities are those that receive the highest number of tourists in the region). Economically, they are municipalities related to the service sector, hence the negative values in Component 3, since some of them act as county seats, as well as municipalities with an economy related to the productive agricultural sector. The positive values in Component 1 determine the high success of the investments, with almost 80% being active, with a similar percentage in active projects and in private investment (it is the third with the best results) (Table 7).

Group 5: is made up of 58 municipalities with an average of 1728 inhabitants per municipality (Table 7). This group presents a positive average in the values of Components 1, 2 and 3, and negative in Components 4 and 5, and these results are explained by the conditions and characteristics of the municipalities that make up the group (Table 6). In this case, the municipalities are located in mountain areas, mainly in the Villuercas (SE of the province of Cáceres) and some mountain municipalities on the border with Portugal (Figure 3). Demographically, it is characterized by being one of the groups that loses more population together with Group 3, reflected in the old age index and in the income, the lowest of the five groups. However, Component 2 shows positive average values, despite the fact that this group presents important population losses. These positive values are determined by its low agricultural unemployment, due to the lack of population, its high success rate despite regressive demographics, and low incomes. Component 3 shows that the economies of these municipalities are linked to the low profitability agricultural sector, with little business fabric. Some municipalities in this group, such as those located in Villuercas, have a rich natural landscape of great value which, due to their remoteness from both Madrid and the highways, have not been able to develop a tourist offer like that of other mountain areas. In the area of public aid, it is the group with the highest investment per inhabitant, with a high active investment. In terms of accommodation, and rural accommodation has been financed the most, with more than 70% of the financed accommodation being active (Table 7). However, although these investments have been high in relation to the number of inhabitants, they have not been sufficient to create a sufficiently dynamic offer to increase the population, increase the young population or increase income.

4. Discussion

In this article, two methodologies have been used with a wide background in the scientific literature that studies Leader and Proder [57–59], although none of them are linked to the study of tourism supply in the long term. For this purpose, variables that have conditioned the sustainability of Leader and Proder (the percentage of investments and projects that are maintained, the type of infrastructure financed and the ratio of investments in relation to the population) have been used, together with other context variables that may have conditioned the survival of tourism businesses. For this purpose, factors such as population growth, both at present and at the beginning of the aid, income, unemployment in the agricultural sector, which is still relevant in the rural areas of Extremadura, and the service sector, have been taken into account as well as other variables, such as access to the main source of tourists in the region, Madrid [22], and to the highways in the regions. We have also taken into account the percentage of protected natural and heritage resources, in order to check whether their existence conditions the success of tourist establishments. The use of these two methodologies will facilitate the establishment of a pattern of the rate of success of investments in tourism in territories with different casuistry. In such a way that the results obtained can be extrapolated to other territories and serve as a reference for the future development of tourism. Based on the results obtained and presented above, it has been possible to verify different trends:

- The municipalities that make up Group 1 and Group 4 are municipalities located in mountainous areas with great natural resources and that have opted for tourism as a way of complementing their agricultural income, with a high rate of active supply and active investment. Within them, Group 1 is made up of municipalities of smaller population size than those in Group 4, which are characterized by being small county seats. In general, they are losing population, but not as much as Group 5, and they are aging, but with lower numbers than other groups. They are located mainly in the northern territories of the region, coinciding with the rural areas with the most tourism [22], which have opted for tourism as the main economic activity along with agricultural and forestry production. These are municipalities that have created tourist activity around a product, in the case of Valle del Jerte, cherries, Valle del Ambroz, autumn landscapes and timber exploitation, or La Vera, agricultural products such as paprika or tobacco. Their active investments are related to the size of the population, being the small municipalities those that have financed mainly rural accommodations. This is due to the fact that they are a type of accommodation with a number of places that rarely exceeds 10 and are easily managed by the family environment. The larger municipalities have managed catering services, which are linked more to the internal consumption of the inhabitants of the municipalities themselves than to the tourism sub-sector.

- The other group with a high success rate is Group 5. This group is located in areas far from the highways and Madrid, with a high aging, scarce business fabric and lower incomes that, although they have invested considerable amounts per inhabitant, are not enough to stop the demographic loss processes. These are territories that in many cases have a high landscape value, such as Las Villuercas or the areas of the reservoirs of La Serena, but that need greater investment to reverse these processes. This is as well as advocating the development of a central tourism product that encompasses the rest of the resources, as has happened in the Valle del Jerte or in the Valle del Ambroz, or in the GAL Tajo-Salor-Almonte with the Torta del Casar, although the latter to a lesser extent. In other words, betting on a single product around which tourism promotion revolves, such as the Villuercas Geopark (Villuercas-Ibores-Jara Geopark), which, despite its scientific relevance, has not achieved tourism development.
- The other two groups have low success rates, both with less than 20% in supply and less than 15% in private investment. On the one hand, they are municipalities that have not invested significant amounts in tourism or that have not destined these investments in the development of tourism, but rather to enhance the value of agricultural and forestry production. Most of them are municipalities located in irrigated and rainfed areas productive with vines and olives, as is the case of the municipalities in Group 2, which, in addition, are growing in population. There are also municipalities with an economy based on the exploitation of natural resources, such as the granite quarries in the La Serena area. On the other hand, there are municipalities that, although they have invested in tourism, are small municipalities that do not have a sufficient previous business fabric to invest in the tourism sector or in general to invest in Leader and Proder. These municipalities are those located in Group 3, which present small aging populations where the reversion of the regressive demographic processes has not taken place.

Thus, the results obtained with PCA and cluster analysis have made it possible to differentiate three patterns according to the five groups established. It can be determined that factors such as the investment made, a greater number of projects, the type of accommodation, the size of the population, the existence of tourist resources and the influence of Madrid are variables that have conditioned the sustainability of the enterprises financed under initiatives such as Leader and disappeared Proder. Despite the lack of studies focused on the viability of tourism businesses, there are other studies that should be mentioned because of the results obtained, since they certify that the results presented are valid. Studies by Nieto Masot and Cárdenas Alonso [28,29], indicate the existence of a concentration of tourism investments in Extremadura. These two studies applied spatial location methods, such as Local Moran's and Getis-Ord, and a statistical method to test the degree of effectiveness and the degree of efficiency in determining an Ideal Point, in this case related to the concentration of tourism investments. The results showed the existence of a concentration of tourism investments and projects in the northern mountain areas of the region, especially in the Proder groups due to the greater flexibility of the regulations. Although this study did not categorize by LAG, it is possible to establish a similarity with the results obtained in the two aforementioned studies, since it was determined that businesses located in mountain municipalities, mostly in the north of the region, have a higher rate of success.

Other studies outside the region, such as that by Candela Hidalgo et al. [23], deal with the potential of tourism promoted by the Leader initiative in mountain areas. This is a case study in mountain areas, close to the Mediterranean coast, which have seen the optimal economic benefits of sun and beach tourism. Although this study does not include an analysis of the sustainability of tourism businesses, nor an analysis with context variables, it does take into account all those projects aimed at improving the tourism offer: accommodations, route signage, museums, interpretation centers, tourism promotions, etc. Despite these differences, several common points have been established: excessive funding for tourism, without taking into account other measures that also allow for economic diversification; and the tendency to concentrate investments in municipalities close to the Rural Development Centers. Also, the study by Frutos Mejías et al. [60], on the evolution of rural tourism during Leader and Proder in Aragón (a region located in northeastern Spain) is noteworthy. This study establishes that thanks to these initiatives there has been an increase in the creation of lodging enterprises, which are located excessively in mountain areas, especially near the Pyrenees and in regions with greater tourist attraction due to their natural resources and where there was already a tourist base with lodging and activities.

These are some examples of analyses carried out at a general level on tourism businesses financed with the Leader Method. Regarding the studies that analyze the long-term sustainability of these businesses, those carried out by Navarro Valverde et al. [33], Castellano-Álvarez et al. [30], or Santos et al. [32], stand out. The first shows that tourism companies have had the greatest continuity (71 out of 100) in comparison with other types of company financed with Leader. This study, unlike the one presented, does not differentiate between types of tourism enterprises, so a comparison cannot be made at the infrastructure level. However, it is possible to make a comparison based on the territory, since the selected LAGs, three LAGs in Andalucía (Southern Spain), have certain similarities with those present in this study, which allows a comparison to be made and once again demonstrates the effectiveness of the model presented. At the territorial level, the study by Navarro Valverde et al. [33], presents three groups: one of them in a mountainous area where agriculture and tourism predominate; another LAG far from the main cities, with less economic development and low population density; the last, close to a large population, with an economic sector linked to this larger municipality. Through surveys, they have determined that those areas where the companies were located in areas with a high natural and landscape value and with a location close to the cities, which allows the urban population to move to the rural areas on weekends or short vacations, have a higher percentage of success. The second article, which was carried out in a LAG in Extremadura through interviews, cannot be extrapolated to the regional level, since it deals with an area with very specific characteristics. These authors state that the areas that already had a previous tourist fabric before these aids were more successful, so it is considered that the existence of a greater number of lodgings favors the survival of the investments. It should be taken into account that the existence of only one accommodation or catering service in a municipality does not produce a positive effect, but because it is isolated and with little or no supply does not generate tourist flows that sustain business over time. It should also be added that in Extremadura the carrying capacity of the tourist offer has not yet been exceeded.

Finally, the article by Santos et al. [32], which, although it does not differentiate between types of company, has been considered for inclusion when dealing with the viability of Leader+ financed businesses in a specific area of Portugal. The study location corresponds to an area bordering Extremadura, which presents socioeconomic characteristics similar to those of the region: ageing population, low population density and an economy based on tourism and the agricultural sector. These authors establish not only that the location and the investment made are important for the viability of the companies, but also that some types of company, such as those providing business support services, have a higher success rate.

In short, the results obtained not only agree with the conclusions of the previous authors, but enable us to determine that the tourism offer has been successful in areas with natural mountain resources, with greater investment and number of financed lodgings, with an intermediate population size and close to urban areas that send out tourists. In addition, it has been shown the existence of rural areas with certain characteristics (which in this study would be the municipalities belonging to Group 1), which, although they have not managed to modify the regressive demographic trends, have managed to soften the loss of population and create solid tourism businesses over time, complementing the income of family farms and including these areas in both national and international tourism markets. Thus, these articles, although with a different methodology and area of study than that presented here, allow us to verify the effectiveness of the method. It is possible to apply this method not only in European rural areas with Leader funding, but it is also possible to apply this methodology in general in tourism and, specifically, in studies on the creation of new businesses of accommodation and catering services in rural areas that are not strictly part of the EU.

5. Conclusions

The changes that took place in European countries during the second half of the 20th century have affected the development of rural areas, which are currently suffering from significant problems of population loss, aging, abandonment and reduced economic development. As a way to mitigate the existing problems, European governments developed a series of initiatives with the aim of slowing down the regressive demographic processes in these areas and activating local economies. Thus, in 1991, the Leader Method was launched, aimed at co-financing new activities in rural areas, encouraging the participation of the local population and promoting endogenous development. During the second call for Leader, Leader II, the number of applications exceeded the budgeted funding, so the Proder Program, complementary to Leader with similar objectives, was approved in Spain. Within Leader and Proder, tourism was positioned as the main activity capable of diversifying rural economies and complementing agricultural income, encouraging the development of a tourism offer that would satisfy the growing demand in rural areas.

Throughout these more than 25 years of Leader and Proder applications, accommodation and catering businesses have been financed; however, their sustainability over time has been scarcely studied. Due to the limitations of previous studies, the project presented here represents not only an innovation in the proposed topic, but also in the methodology used. The methodology applied has made it possible to establish several patterns depending on the degree of success of the aid and different contextual variables that can be replicated in other territories. Thus, investment is fundamental, but it is not a determining factor in the success of these businesses. An ideal location, at a distance of less than 3 h by car from municipalities that send out tourists, the existence of natural and heritage resources, investment in rural accommodation and greater economic dynamism, especially focused on the agricultural sector and the service sector, benefit the success of the businesses. Demographically, it has been detected that businesses located in areas with high rates of aging and a small population size can survive if the above characteristics are present. Leader and Proder actions have been necessary in all rural areas of Extremadura because they have favored the creation of accommodation infrastructures. The most successful areas (with a percentage above 70%) are located in areas with the most optimal conditions (proximity to Madrid, existence of natural resources, water resources, etc.). In the less successful areas, despite the fact that they present the optimal external and internal conditions for the development of tourism, it is necessary to continue implementing these initiatives with a focus on quality tourism.

In conclusion, there is a need for studies such as this one, allowing us to see the weakest points of aid and thus optimize resources by modifying and addressing new measures with greater effectiveness and efficiency. In the case of Extremadura, tourism with Portugal should be promoted, especially in border areas, so that those areas with lower investment and profitability increase their success rates. In addition, it is necessary to increase the volume of aid in areas with a lower degree of success, to enable them to offer a greater number of accommodation and catering services. Another important point is the development of integrated and complementary offers that do not compete with each other. Finally, it is necessary, in the case of the region under study, to improve accessibility (better trains and access to international airports such as Sevilla, Madrid or Lisbon), as well as the dissemination of the territories at regional, national and international levels through the development of new technologies. In future research, it would be interesting to analyze how the current pandemic situation has affected this region, since due to the restrictions and limitations, these businesses will have lost part of their activity, and therefore part of their profits.

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Article

Farmland Rental Participation, Agricultural Productivity, and Household Income: Evidence from Rural China

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Abstract: The rural land rental market is playing an increasingly important role in the agricultural transformation period for developing countries, including China, where rural farmland rental is highly context-specific with the implementation of the collective-owned rural land system; thus, in turn, the access to farmland rental markets for rural households has profoundly influenced their livelihood strategies and income earnings. This paper investigates the income impact differences caused by rural households' farmland rental participation activities and explores such impact mechanisms by further evaluating the income impacts caused by rental area and household agricultural productivity. Data from the Chinese national household survey were used for estimating the empirical models. Our results show that farmland renting has positively affected households' on-farm and total income, but there is no significant effect upon off-farm income. According to income differences across quantiles, we find households with high on-farm income are more sensitive about enlarging their farm size by renting farmland, and households with middle and upper-middle off-income may benefit more from renting out their farmland. Furthermore, the joint effects of renting area and household agricultural productivity on lessee households' farm income is significantly positive. For lessor households, our results indicate that renting out farmland did not improve their off-farm and total income as it may have a limited effect on farm household labor distribution. Our findings suggest that engaging in farmland rental activity can enhance farming productivity efficiency and poverty alleviation among rural households. Under the collective-owned rural land system, it is urgent and necessary to initiate and design incentive policies to encourage highly efficient large farms to expand the farm size and provide smallholders with equal opportunities to engage in farmland rental activities.

Keywords: farmland rental market; household income; agricultural productivity; rural land reform

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1. Introduction

Farmland is the primary production means in agrarian economies, and a well-functioning land market is necessary for enhancing land use efficiency and contributing to agricultural development. A growing branch of literature has been addressing the significant role played by farmland rental markets in increasing income and farmland distribution equity among farm-owning households in developing countries [1–7], including China [8,9], where the rural farmland rental market is highly context-specific with the practice of collective ownership [10].

The most significant difference between farmland rentals in China and other countries is that only farmland management rights can be transferred to lessee units. At the same time, the village collective retains the ownership and the lessor households keep the contractual rights [10,11]. Chinese rental markets hold more importance as a land redistribution mechanism rather than as means of administrative reallocation [10]. Over the decades since the beginning of the Household Responsibility System (HRS) land reform (1978), many changes have occurred in the farmland rental system, from the prohibition of farmland rentals among farmers to the legalization of farmland rental activities. The HRS initially marked dramatic changes for land tenure institution and production relations—chiefly, a shift from collective farming to household-based farming [12]. HRS was widely recognized as a successful reform for stimulating rural households' incentives to increase their production yield, boosting autarkical small-scale farming in rural China [13,14]. With the requirement for intensive farming and the growth of off-farm work opportunities among farmers, the farmland rental market emerged after almost two decades of HRS reform [15]. In 2014, the Three Property Rights Separation (TPRS) reform reconstructed the farmland property rights system and further separated land management rights from land contractual management rights by legalizing national farmland rental practices [14]. By the end of 2020, the total farmland rental area reached 37 million ha[1], which accounted for 30% of the total farmland area in China.

Farmland is a fundamental asset for determining rural households' livelihood strategies [16,17]. Thus, farmland rental participation is strongly associated with the reallocation of land holdings and labor endowment distribution between farming and non-farming activities; it therefore affects household income earnings. Previous studies have documented that increasing household farm size by renting farmland from others ("rent in") can enhance agricultural output and farm income [7,18–20]; however, renting out farmland ("rent out") had a limited and mixed effect on farm income [6,19]. Furthermore, the impact of farmland rental on off-farm income remains controversial [19,21,22]. Studies on the exact impact mechanism of farmland rentals on household income have been neglected despite the merits. Household agricultural productivity holds important implications for determining farmland rental strategies, which have not attracted adequate research attention thus far. Farmland rental markets facilitate the transfer of land use rights from less effective producers to households with higher agricultural capabilities through the farmland rental market [7,10].

Moreover, the close correlation between productive efficiency and farm size implies that the household on-farm income may be affected by households' agricultural production conditions and the amount of area being rented or rented out [23–26]. For rural households with off-farm earnings, it is unclear whether the increase or decrease in non-agricultural labor inputs brought about by land outflow (inflow) can affect such households' off-farm incomes. In this regard, this paper aims to investigate income impact differences resulting from rural households' farmland rental activities and explore this impact mechanism by further evaluating the income impacts of farmland rental area and household agricultural productivity. Specifically, employing data from the Chinese national household survey, we empirically used OLS and IV regression to examine the average impact of farming households' farmland rental market-related decision making on household income and the effects of farmland rental area and household agricultural productivity on the former impact mechanism. We also employed Quantile Regression (QR) to investigate income differences among households with different income levels as a robustness test and to provide a more complete picture. This study thus contributes to the literature on the influence underlying farmland rental on rural households' incomes and also has some essential value for policymaking in terms of assessing the potential for reducing rural income inequality and improving agricultural modernization by enhancing farmland access for farmers through newly formed farmland markets.

This paper is further structured as follows. Section 2 discusses the institutional background of the farmland rental market in rural China. Section 3 reviews related theories and delivers key hypotheses accordingly. Section 4 presents model specifications, estimation strategies, and data sources. Section 5 presents empirical results, followed by Section 6, which contains results-based discussions. Section 7 concludes with findings and policy implications.

2. Institutional Background

2.1. Household Responsibility System (HRS) and Smallholders' Agricultural Production Performance

Institutionalization of land property rights has always been a central issue in political economy development for nation states throughout history [27,28], including China. Since the reform and opening-up in 1978, the Chinese government has implemented a series of rural reforms to develop the rural economy. Among the reforms, the most remarkable change was the emergence of the Household Responsibility System (HRS), which separated land contractual management rights from collective ownership, thus greatly stimulating rural economic development and urbanization in China [29]. The official universally acceptable implementation of HRS resulted from farmers' institutional choice [30], thus reinstating individual households (instead of "collective production teams") as units of agricultural production.

Under HRS, individual village households were granted a particular share of farmland depending on family size and allowed to retain rights to utilize and operate the farmland. When HRS was initially implemented, farmland could not be transferred among households, and the reallocation of farmland shares among farm units was explicitly disallowed to retain each landholder's land tenure security. Since the farmland was not allowed to be leased among small-scale production units, some hotly debated concerns have emerged, including dwindling farm size and fragmented farming units [31–33]. A few arguments even believe that excessive farmland fragmentation will reduce the agricultural productivity [34]. There was abundant evidence to show that small landholdings under HRS could generate incentives for households to improve their agricultural performance—in the early years after HRS was introduced (1978–1984), great incentivizing changes under HRS were regarded as the dominant source of agricultural output growth [9,35–37].

However, since the 1990s, advancements in agricultural production technologies, changes in agricultural labor, and rapid industrialization and urbanization processes reduced the proportion of rural economy contributions made under the HRS [36,38,39]; this situation induced farmland rental behaviors and rural farmland market functions.

2.2. The Development of Farmland Rental Market and Market-Oriented Reforms

After 1984, China's agricultural output growth stagnated with a remarkable decline in collective agricultural investments [9,40,41]. Several studies have shown that incomplete land tenure and associated property rights for household responsibility farmland can reduce long-term farmland security, thus leading to low agricultural investment levels among farmers [42]. By its very nature, positive reactions to HRS reforms were mainly adaptive improvements in household labor productivity, while traditional patterns produced through small-scale household production did not change (Hong and Wang, 2019). Meanwhile, post-1978 market economy growth accelerated rural farmland rental market development, gradually exposing the unadaptable issue of incomplete rural farmland property rights in the growing area of farmland rental activities. After dramatic changes involving rural land policies, including the extension of duration for rural farmland contractual management rights (introduced in 1998 Land Law, 2003 Rural Land Contract Law, and 2007 Property Law), the abolition of agricultural taxes for responsibility farmland (introduced in 2006 No. 1 central document of CPC), and the permitting of farmland rental market development (introduced in 2003 Rural Land Contract Law), the security of responsibility farmland was deeply strengthened.

Rapid urbanization, on another note, promotes the continuous migration of agricultural labor to urban sectors, and this allocation of labor forces led to the growing popularity of farmland rental markets in rural areas [15,43] (Figure 1 depicts the increasing amount of farmland rental activities over the past decade). The farmland rental market has developed rapidly with the emergence of specialized farming units (including family farms and agricultural enterprises). In three years (2015–2017), 55% of total rented farmland was obtained by intensive farming producers, agricultural enterprises operated 32%, and 13% was obtained by other business entities [44].

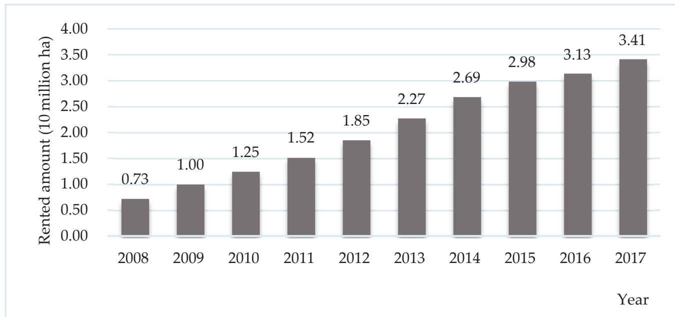


Figure 1. The variation of the total rented farmland area nationwide (2008–2017). Resource: Ministry of Agriculture and Rural Affairs of the People's Republic of China.

After the introduction of HRS, to enhance property rights-related security for both outflow entities (farmland contractors) and inflow entities (farmland producers), farmland rental policies have experienced a shift from strictly forbidding open-market rentals to allowing unfettered rental of farmland [45]. In 2014, the Three Property Rights Separation (TPRS) reform further separated land contractual right and management right from land tenure—and thus enhanced farmland tenure security by improving property rights stability [46]. This 2014 TPRS reform has essentially legalized farmland rental practices over the past few decades, which was intended to create a relaxed institutional environment for a well-functioning farmland rental market [47].

3. Theoretical Framework

3.1. Farmland Rental and Its Income Impacts

The TPRS reform in China divides farmland property rights into collective ownership rights, contractual rights, and management rights. Within the contract period, the management right is the only transferable right, and the contractual right should always be retained by the farmland contract household [14,48]. Thus, under the "three property rights" structure, all rural households could be divided into three groups based on what property rights they can retain and enjoy (see Figure 2):

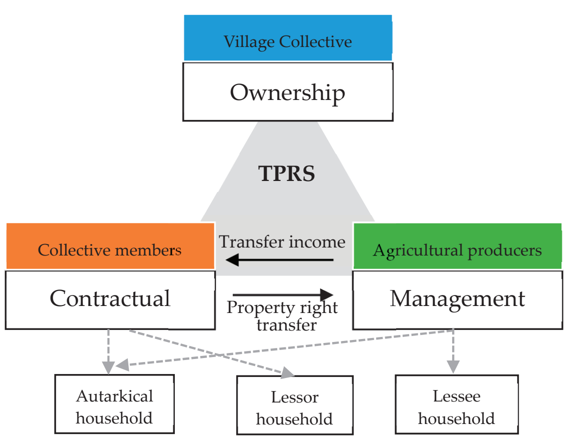


Figure 2. The possession status of farmland property rights among rural households under the TPRS system.

The first group includes autarkical households who do not participate in any rental activities; they enjoy complete contractual management rights over their responsibility farmland. The second group includes lessor households who only retain contractual rights and rent out their responsibility farmland's management rights to other farming units. The third group includes lessee intensive farming households with large landholdings. They borrow farmland from lessor households to enlarge their farm size and probably increase their investment in farming production to achieve higher agricultural productivity [49,50]. For the rented rental farmland, they only retain management rights. Through the participation in the farmland rental market, rural households' livelihood strategies and income earnings were profoundly influenced by the reallocation of land–labor resources inputs [51,52].

Few pieces of research have examined the mechanisms underlying the influence of farmland rentals on household income [6,19]. Theoretically, rural households' on-farm and off-farm incomes are expected to be influenced as follows:

(i) For renting out (lessor) households. Renting out farmland could lead to a decline in farmland size, with surplus labor and other inputs leaving on-farm activities, thus decreasing farm income. Off-farm income is expected to increase significantly along with rental income received from tenants since labor forces released from on-farm activities are able to obtain higher wages through off-farm employment. Thus, total household income would improve significantly.

(ii) For renting in (lessee) households. Farmland rental is economically efficient because it allows highly farm-efficient households to increase their farm size by renting in farmland from low-efficiency households. For specialized households renting in farmland from lessor households, operational landholdings could significantly increase [49,50]. Consequently, on-farm income for such households could improve if net farm revenue is higher than the payment for rented land [19]. Accordingly, the first hypothesis of this study was proposed as follows:

Hypothesis 1 (H1). *Participating in farmland rental activities will raise rural household income. For lessee households, farmland rental will boost their on-farm income; while for lessor households, farmland rental will increase their off-farm income significantly.*

3.2. Farmland Rental Area, Productive Efficiency, and Household Income

Productive efficiency is a crucial factor affecting rural households' farmland rental strategy. With the permission for farmland rental to occur freely, highly efficient producers are more likely to increase farm size by renting land shares from others, and less efficient producers tend to rent out their land and engage in other off-farm work. Therefore, the close relationship between farm size and household productive efficiency directly affects household income. In this regard, it is worth recapping the incentive-related debates regarding the relationship between farm size and agricultural productive efficiency outlined by agricultural economics. The economic theory proposed that agricultural productivity should be equal across farms [53]; however, in empirical studies, the inverse "size-productivity relationship" of farming is widely accepted in low-income economies [54–64]. One dominant reason for this situation is that these developing economies' factor markets are imperfect. Without modern machinery, small-scale farming enjoys significant advantages over larger units, as labor costs form the bulk of total agricultural costs [65]. Moreover, land markets are also highly imperfect in underdeveloped rural areas, so farmland cannot be reasonably allocated or transferred to highly efficient small farmers. This situation allows such smallholders to obtain higher land productivity by replacing land with labor and generating more agricultural land income.

However, when the country's economy begins to develop with increased use of capital-intensive technology, agricultural machinery, and hired labor, scale economy's advantages emerge in larger farms. Larger and more mechanized farms increase technical efficiency and productivity in agricultural performance [65]. Evidence from such developed economies has confirmed that small farms are less technically efficient [66], while large farms have much higher labor productivity and cost efficiency, which is gained by taking advantage of the scale and diversification economies [23,25,67].

Currently, China is undergoing a transition period in its goal of achieving agricultural modernization. The conventional claim that "small is beautiful"—which is proved by Chinese studies' empirical observations that small farms' agricultural productivity is higher than that of larger farms [68–70]—is being challenged by the factor-market economy development and massive farmland rental movements, which are promoted by the Chinese government [24,71]. Recent Chinese studies show that the increase in farm size benefits farmers' net profit, as well as economic, technical, and labor efficiency [72]. Furthermore, agricultural productivity increases with farm size over the years [10,24,26]. Meanwhile, some scholars are attaching great importance to optimal sizes for Chinese farms during the transition period; this issue concerns farmers' primary livelihood and the country's food security. Regarding the area of farmland rental and agricultural productivity, few empirical studies have addressed this issue thus far. Highly farming-efficient households tend to rent farmland from other units. Most such households are specialized farming units (family farms or agricultural enterprises) with farming machinery or equipment. According to existing literature, renting farmland from other households indicates better agricultural labor productivity [73]; furthermore, it will significantly increase agricultural productivity. Accordingly, the second hypothesis regarding the positive relationship between farmland rental area and agricultural production would be put forward as:

Hypothesis 2 (H2). *Agricultural productive efficiency will significantly improve household on-farm income. Lessor households' on-farm income will decline with increases in rental area, and off-farm income will increase with labor migrations to off-farm sectors. For lessee households, increasing farmland rental area will improve their on-farm income; however, simultaneously, the interaction between the farmland rental area and agricultural productive efficiency will positively affect their agricultural income.*

4. Methods and Data

4.1. Model Specification and Estimation

4.1.1. Empirical Model Specification

First, a simple production model was constructed to trace how farmland rental affects households' income. Each household, i, has the labor force endowment, L_i, A_i units of owned responsibility farmland, and a given agricultural efficiency, a_i. To generate income, rural households can input labor and land to produce agricultural output, which follows the production function f ($a_{i,on\text{-}farm}$, $L_{i,on\text{-}farm}$, $A_{i,on\text{-}farm}$), where $L_{i,on\text{-}farm}$ and $A_{i,on\text{-}farm}$ represent the labor and farmland used for generating agricultural income [8,74]. Household income depends on the market value of agricultural output and earnings from off-farm employment. Accordingly, we expressed household income as follows:

$$I_t = I_{on-farm} + I_{off-farm} = pf\left(\alpha_{i,on-farm}, L_{i,on-farm}, A_{i,on-farm}\right) + wL_{i,off-farm} \tag{1}$$

Farmland rental participation behaviors influence the land input and further on the earnings from on-farm activities. Specifically, to depict how participation in farmland rental markets affected household income, we construct the income-generating functions for renting out households and renting in households as follows.

Renting out households' total incomes include income from renting out farmlands and working on off-farm activities. That is,

$$\begin{aligned} I_{out,i} &= I_{out,on-farm} + I_{out,off-farm} \\ &= pA_{out,i} - p_0 f\left(\alpha_i, L_{out,i,on-farm}, A_{out,i}\right) + wL_{out,ioff-farm}, \end{aligned} \tag{2}$$

where the total labor of the renting out households is estimated as follows: $L_{out,i,t} = L_{out,i,t,on-farm} + L_{out,i,t,off-farm}$; here, $L_{out,i,t,off-farm}$ represents the labor force working on renting out households' off-farm activities. p_0, p, and w represent the standardized average prices of agricultural products, rental lands (i.e., rents), and wages from off-farm activities, respectively. Moreover, $A_{out,i}$ denotes the amount of outflow area held by household i, and $f\left(\alpha_i, L_{out,i,t,on-farm}, A_{out,t,i}\right)$ demonstrates the production function of the renting out households; this implies that the productivity of their on-farm activities primarily depends on labor and rental land inputs.

However, renting in households' total incomes include profits from farming on rental lands (i.e., farming incomes minus rental costs) and remunerations from the off-farm work. Thus,

$$
\begin{aligned}
I_{in,i,t} = I_{in,on-farm} &- C_{in,on-farm} + I_{in,off-farm} \\
&= p_0 f\left(\alpha'_i, L_{in,i,on-farm}, A_{in,i}\right) - pA_{in,i} + wL_{in,i,off-farm}
\end{aligned}
\tag{3}
$$

where total labor performed by renting in households is calculated as follows: $L_{in,i,t} = L_{in,i,on-farm} + L_{in,i,off-farm}$; $A_{in,i,t}$ denotes the amount of inflow area held by household i in the year t. Furthermore, $f\left(\alpha'_i, L_{in,i,on-farm}, A_{in,i}\right)$ demonstrates the production function of the renting in households.

Furthermore, to estimate the impact of rural households' participation in farmland rental markets on household income, we empirically discussed the influence of farmland rental choices on household incomes (H1) along with relevant influencing mechanisms in terms of rental area and agricultural productivity (H2). Specifically, based on research questions and hypotheses, household income (I) was treated as the dependent variable, which was used for illustrating household on-farm income, off-farm income, or total income when examining different hypotheses. Next, dummy variables reflecting household farmland-related rental choices (If_rentin or If_rentout), the amounts of rental area that reflected the farmland rental scale (In_area or Out_area), and the agricultural productivity (Agr_eff) were considered as the core explanatory variables. Furthermore, we examine the cross effect of farmland outflow scale and off-farm working hours (Off_hour) to identify whether there is a significant moderating effect between farmland rental participation and non-agricultural employment input. Based on these considerations, the reduced-form income equation could be expressed as follows:

$$I = \alpha + \beta_1 If\_rentin + \beta_2 If\_rentout + \gamma V + \varepsilon \tag{4}$$

$$I_{in,on-farm} = \delta + \theta_1 In\_area + \theta_2 Agr\_eff + \theta_3 (In\_area * Agr\_eff) + \rho V + \varepsilon \tag{5}$$

$$
\begin{aligned}
I_{out,on-farm} = \delta' \quad &+ \theta'_1 Out\_area + \theta'_2 Agr\_eff + \theta'_3 (Out\_area * Agr\_eff) \\
&+ \rho' V + \varepsilon
\end{aligned}
\tag{6}
$$

$$
\begin{aligned}
I_{out,off-farm} = \quad &\delta'' + \theta''_1 Out\_area + \theta''_2 Off\_hour \\
&+ \theta''_3 (Out\_area * Off\_hour) + \rho'' V + \varepsilon
\end{aligned}
\tag{7}
$$

where β, θ, γ, and ρ refers to the regression coefficients of the corresponding independent variables and control variables (V); ε represents the disturbance term with standard properties. The more detail variable selection considerations are explained as follows:

(i) Household income. This study classified household income into on-farm income and off-farm income. On-farm income refers to income obtained by farming households as agricultural production and operation units on the farm. Off-farm income considered in the study contains wage income (mainly from off-farm employment), business income, property income, and transfer income. Rental income received from farmland rental activity was included with property income derived from land assets. Thus, the dependent variables contained the household's total income and its components (on-farm income and off-farm income).

(ii) Household farmland rental participation choice. Two dummy variables indicating whether a household participated in farmland rental activities (If_rentin or If_rentout) were included in the models as an indicator of household farmland rental decisions. When farming households choose to rent out their farmlands (i.e., If_rentout = 1), they become free from agricultural activities and are thus more likely to migrate to cities to find non-agricultural jobs; this could decrease on-farm income and increase off-farm incomes.

(iii) Household farmland rental area. According to the given income-generating functions, it is evident that on-farm income is directly correlated to the household farmland rental scale. Thus, we used the amount of outflow or inflow area (In_area or Out_area) to discuss the specific influence of farmland rental activity on household incomes. Farmlands are viewed as a crucial agricultural production factor, so when rural households rent out more farmlands, on-farm income will decline more significantly. In other words, for renting in households, increasing farmland rental area could improve their on-farm income.

(iv) Household agricultural productivity. Household agricultural productivity is affected by farmland renting and has impacts on household income, especially on-farm income. Therefore, we used the average annual unit output to measure agricultural productivity (Agr_eff) and further explored its influence on income in different groups of households.

(v) Control variables. Control variables in the models mainly included other certain production input variables and demographic characteristics. Table 1 reports the definitions and summary statistics of this study's employed variables.

Table 1. Description and descriptive summary of the key variables.

Variable name	Description	Observations	Mean	Std. Dev.	Min	Max
Household income						
On-farm income	Income generated from agricultural production (yuan/year)	11,591	8130.68	50,912.67	0	3×10^6
Off-farm income	Income generated from off-farm activities (yuan/year)	11,597	23,915.62	84,360.27	0	6×10^6
1.Wage income	Wage earnings (yuan/year)	11,604	16,962.60	30,600.85	0	318,000
2.Business income	Income generated from family business activities (yuan/year)	11,597	1857.51	65,697.21	0	6×10^6
3.Property income	Income generated from managing household owned movable property and real estate (yuan/year)	11,604	614.24	12,811.70	0	1×10^6
4.Transfer income	Income received from transfer payments (such as retirement pension, dismissal payment, housing accumulation fund, etc.).	11,604	4473.18	41,074.88	0	4×10^6
Farmland rental						
If_rentout	Whether such household participates in farmland renting out (dummy variable, if yes = 1)	9748	0.14	0.35	0	1
Out_area	Amount of outflow area (mu *)	9708	0.79	10.63	0	1000
If_rentin	Whether such household participates in farmland renting in (dummy variable, if yes = 1)	11,587	0.14	0.35	0	1
In_area	Amount of inflow area (mu *)	11,562	2.03	13.91	0	650
Production input						
Agr_eff	Annual agricultural output yield (kilogram/mu *)	4042	363.17	402.24	0	2925
Farmland_area	Household contractual responsibility farmland area (mu *)	9384	4.91	3.56	0.3	60

Table 1. *Cont.*

Variable name	Description	Observations	Mean	Std. Dev.	Min	Max
Land quality	The average quality of household farmland (1. very poor, 2. poor, 3. average, 4. good, and 5. very good)	9720	3.29	1.00	1	5
Agr_input	Annual investment in agricultural production (including costs of fertilizers, pesticides, seeds, rental machinery, hired labor etc., yuan/year)	10,562	4278.98	7657.88	0	64,100
Agr_labor	The number of family members engaged in agricultural production	8446	1.96	0.91	0	14
bus_hour	Average daily business hours per family member(hours)	11,527	0.96	3.20	0	24
work_hour	Average daily working hours per family member(hours)	11,604	1.92	3.93	0	24
Household characteristics						
Head_gender	Gender of household head (female = 1; male = 2)	11,604	1.88	0.33	1	2
Head_age	Age of household head (years old)	11,603	55.68	12.54	3	99
Head_edu	Educational level of household head (1. no schooling, 2. primary school, 3. junior high school, 4. senior high school, 5. technical secondary school/vocational high school, 6. junior college/vocational college 7. undergraduate, 8. master, and 9. doctor)	11,588	2.48	0.98	1	7
If_official	One (or more) family member is village official (dummy variable, if yes = 1)	8372	0.06	0.24	0	1
Family size	Number of family members	11,604	4.11	1.93	1	19
Health_condition	Average health status of family members (1. very good, 2. Good, 3. Average, 4. Bad, and 5. very bad)	11,602	2.74	0.81	1	5
Instrumental variables						
Share_out	Share of households participating in renting in farmland activity at provincial level (%)	11,604	0.14	0.04	0.01	0.26
Share_in	Share of households participating in renting out farmland activity at provincial level (%)	11,604	0.14	0.03	0.09	0.22
Land_title	Whether the household was issued with land title registration (dummy variable, if yes = 1)	9446	0.45	0.50	0	1

* 'mu' denotes a unit of area (=0.0667 hectares).

4.1.2. Estimation Method

The Equations (4)–(7) were first estimated using ordinary least squares (OLS) regression, which provides mean results for the relationships between explanatory variables and dependent variables. It should be noted that rural household's choice on participation in farmland rental may be endogenous since there are unobserved variables (such as policies of intervening farmland rental market or guiding rural households' employment) that may influence households' farmland rental choice and income level. In order to solve the potential endogenous issue, the instrumental variable (IV) approach was applied. Specifically, the share of households participating in farmland rental activity at the district level could be used as the instrumental variable. In Zhang's study [19], the share of households in the village participating in the farmland rental market has been confirmed to be served as a proxy for transaction costs in the farmland rental market and it is positively correlated with household's rental decisions but has no direct influence on household income earnings. Our database enables us to calculate the provincial-level farmland rental share, which reflects the implementation status of the national policy to guide farmland rental activity for each province. To make the instrumental variable more reflective of the local context, we employed land title registration issued by the grass-roots government as the cross-term for the provincial-level farmland rental share, since a household with a land certificate is more likely to participate in farmland rental activity if they have secure property rights in law. In this case, Equation (4) is estimated using both ordinary least squares (OLS) and two-stage least squares (2SLS) regression.

Additionally, to provide a more complete picture, a quantile regression (QR) method was then used to explore the income impact differences from households' choice on farmland rental participation for households at various quantiles of the income distribution. This provides more robust results by permitting natural generalization to the linear model [75] and has been regarded as a more complete statistical model than mean regression [76]. We divided all the samples into five quantiles (0.1, 0.25, 0.5, 0.75, and 0.9) for a set of income distributions.

The specific descriptions of all variables are provided in Table 1.

4.2. Data Source

This study used data from a national household survey conducted by the China Household Finance Survey (CHFS). The CHFS was designed to construct a nationally representative micro-database to collect household finance information to provide a comprehensive and detailed picture of household economic and financial behavior. This longitudinal survey included a rich questionnaire for assessing housing assets, financial wealth, income and consumption, demographic characteristics, etc., of residents nationwide, which covers 29 provinces, 363 county-level units, and 40,000 households. More information about this database could be known from [77]. This study's analysis used the data of the 2015 wave from CHFS and it only focused on rural households who contract responsibility farmland from village collectives.

Using the data, we summarized the descriptive statistics of all variables in Table 1. The average on-farm income of all households is 8130.68 yuan, and the average off-farm income is 23,915.62 yuan. Among our samples, the percent of households participating in the farmland rental market was 28.25% (lessor: 13.94%; lessee: 14.31%).

Rural household income is summarized by on-farm income, off-farm income and total income; the rural households are divided into lessor households, lessee households, and non-participating households. The summary shows (see Table 2) that the annual average income from on-farm production is 8130.68 yuan—significantly lower than average income from off-farm activities (23,915.62). Regarding income differences, lessee households' average on-farm income (17,450.18 yuan) far exceeded that of non-participating households (7038.51 yuan) and lessor households (3543.089 yuan). For all groups, off-farm income was the primary household income source. Lessor households earned more off-farm income (30,508.11 yuan) than lessee households (22,774.5 yuan), with non-participating households earning a lower off-farm income (21,574.97 yuan). Regarding total income, compared with non-participating households (30,181.02 yuan), the lessor (34,079.13 yuan) and lessee (40,245.48 yuan) household incomes were much higher.

Table 2. The income differences among households.

	On-Farm Income		Off-Farm Income		Total Income	
	Observations	Mean (yuan) (Std. Dev.)	Observations		Observations	Mean (yuan) (Std. Dev.)
Rent out households	1305	3543.089 (44,104.23)	1305	30,508.11 (49,289.11)	1304	34,079.13 (66,074.62)
Rent in households	1654	17,450.18 (44,606.01)	1658	22,774.50 (105,124.2)	1654	40,245.48 (114,952.40)
Autarkic households	8632	7038.501 (52,771.12)	8635	23,139.17 (84,042.72)	8627	30,181.02 (100,301.90)

Note: The standard errors are given in parenthesis.

5. Results

5.1. Farmland Rental Participation and Household Income

First, we discussed the results of household farmland rental choice-related average income impacts. Before using the IV model to complete the estimation, we examined the validity of our instrumental variables. According to the results of 2SLS first-stage regression (Table 3), the coefficients on our instrumental variables, namely, the cross-terms of rental services and farmland renting in/renting out share, were significant at 1% significance level (p = 0.000), which suggests the instrumental variables have good interpretive power for explaining the host variable. Furthermore, several tests were conducted to check the strength of the instrumental variables. The F-statistics of the first-stage regressions were larger than the threshold value of 10 [78], and the Cragg–Donald minimum eigenvalue statistics were larger than the critical value of each model for the nominal 5% Wald test, suggesting that the instrumental variables satisfied the strength requirement.

Table 3. 2SLS first-stage regression results.

Variable Name	Total Income		On-Farm Income		Off-Farm Income	
	If_Rentin	If_Rentout	If_Rentin	If_Rentout	If_Rentin	If_Rentout
Share-in×Land_title	0.2642 *** (0.0884)		0.1956 *** (0.1010)		0.2735 *** (0.0745)	
Share-out×Land_title		0.1641 *** (0.0638)		0.2019 *** (0.0695)		0.2120 *** (0.0594)
Observations	3394	3394	2792	2792	5097	5097
F-statistic	17.82 ***	14.54 ***	19.29 ***	13.73 ***	24.10 ***	21.74 ***
Minimum eigenvalue statistic	19.66	17.70	14.00	18.32	24.82	24.09

Note: (i) The above table only reports the estimation results of instrumental variables on endogenous variables (farmland rental participation decision variables). (ii) The standard errors are given in parenthesis. (iii) *** $p < 0.01$.

Table 4 presents the OLS and 2SLS second-stage regression results. Overall, the 2SLS second-stage regression results marginally differ from the OLS regression results, with the signs, figures, and significance of coefficients on host and other independent variables not showing obvious changes compared with the results of the OLS model. According to the estimated results, the coefficients on renting in farmland choice in columns (5) and (7) are positively significant and the coefficients on renting out farmland choice in columns (6) and (8) are negatively significant, suggesting that farmland inflow/outflow has a mostly direct impact on on-farm income level. This means that participating in farmland rent in activity has a positive and significant relationship with household on-farm income while farmland rent out activity significantly reduces household on-farm income; this finding partially verifies our Hypothesis 1.

Table 4. The effects of farmland rental participation on household income.

	Total Income				On-Farm Income				Off-Farm Income			
Variable name	OLS (1)	OLS (2)	2SLS (3)	2SLS (4)	OLS (5)	OLS (6)	2SLS (7)	2SLS (8)	OLS (9)	OLS (10)	2SLS (11)	2SLS (12)
If_rentin	0.1986 ***		1.1246 **		0.2636 ***		0.7020 ***		0.0573		1.5128	
	(0.0482)		(1.3495)		(0.0537)		(1.4977)		(0.0515)		(1.0681)	
If_rentout		0.1029		0.7309		−0.1842 **		−1.5441 ***		0.0731		1.8395
		(0.0883)		(2.8278)		(0.0868)		(1.5547)		(0.0761)		(1.5598)
Farmland_area	0.0220 ***	0.0214 ***	0.0305 ***	0.0187 ***	0.0427 ***	0.0420 ***	0.0405 ***	0.0424 ***				
	(0.0026)	(0.0026)	(0.0056)	(0.0039)	(0.0031)	(0.0031)	(0.0052)	(0.0033)				
Land_quality	0.0830 ***	0.0825 ***	0.0805 ***	0.0258 ***	0.0871 ***	0.0886 ***	0.0821 ***	0.0656 ***				
	(0.0202)	(0.0202)	(0.0292)	(0.0426)	(0.0210)	(0.0210)	(0.0225)	(0.0286)				
Agr_eff	0.0002 ***	0.0002 ***	0.0002 ***	0.0001 ***	0.0002 ***	0.0002 ***	0.0002 ***	0.0002 ***				
	(3.81×10^{-5})	(3.7×10^{-5})	(0.0001)	0.0001)	(4.9×10^{-5})	(4.5×10^{-5})	(0.0001)	(0.0001)				
Agr_labor	−0.1102 ***	−0.1087 ***	−0.1126 ***	−0.0403 ***	0.0690***	0.0667 ***	0.0710 ***	0.0906 ***				
	(0.0266)	(0.0267)	(0.0365)	(0.0541)	(0.0260)	(0.0260)	(0.0276)	(0.0341)				
Agr_input	1.24×10^{-5} ***	1.60×10^{-5} ***	3.71×10^{-5} *	2.52×10^{-5} ***	4×10^{-5} ***	4.4×10^{-5} ***	5.41×10^{-5} ***	4.53×10^{-5} ***				
	(3.19×10^{-6})	(3.10×10^{-6})	(2.36×10^{-5})	(6.35E $\times 10^{-6}$)	(3.43×10^{-6})	(3.35×10^{-6})	(2.33×10^{-5})	(3.86×10^{-6})				
Bus_hour	0.0536 ***	0.0533 ***	0.0531 ***	0.0306 ***					0.0110 ***	0.0144 ***	0.0204 ***	0.0068 ***
	(0.0068)	(0.0068)	(0.0099)	(0.0167)					(0.0066)	(0.0067)	(0.0078)	(0.0099)
Wage_hour	0.0685 ***	0.0672 ***	0.0841 ***	0.0496 ***					0.0993 ***	0.1000 ***	0.1185 ***	0.0927 ***
	(0.0046)	(0.0046)	(0.0096)	(0.0124)					(0.0043)	(0.0044)	(0.0128)	(0.0074)
Head_gender	0.1398	0.1338	0.2915	0.2314	0.0168	0.0026	0.0245	0.0434	0.0997	0.1209	0.2568	0.1543
	(0.0692)	(0.0697)	(0.1163)	(0.1223)	(0.0677)	(0.0676)	(0.1090)	(0.0792)	(0.0736)	(0.0756)	(0.1103)	(0.0907)
Head_age	0.0031	0.0024	0.0085	0.0084	−0.0046	−0.0049	−0.0069	−0.0071	0.0052 ***	0.0053 ***	0.0119	−0.0025
	(0.0021)	(0.0021)	(0.0036)	(0.0066)	(0.0021)	(0.0021)	(0.0039)	(0.0028)	(0.0020)	(0.0021)	(0.0049)	(0.0052)
Head_edu	0.1470 ***	0.1441 ***	0.1918 ***	0.1321 ***	0.0851 ***	0.0804 ***	0.0685 ***	0.0778 ***	0.0784 ***	0.0731 ***	0.0996 ***	0.0740 ***
	(0.0226	(0.0226)	(0.0369)	(0.0354)	(0.0225)	(0.0225)	(0.0374)	(0.0249)	(0.0219)	(0.0225)	(0.0289)	(0.0265)
If_official	0.1106	0.1140	0.1047	0.2563 *	0.1331	0.1275	0.1188	0.1690	0.0961	0.0668	−0.0109	0.0856
	(0.0763)	(0.0765)	(0.1099)	(0.1250)	(0.0894)	(0.0903)	(0.0978)	(0.1050)	(0.0762)	(0.0779)	(0.1010)	(0.0931)
Family_size	0.1765 ***	0.1749 ***	0.1773 ***	0.1839 ***	−0.0201	−0.0198	−0.0212	−0.0227	0.2110 ***	0.2172 ***	0.2131 ***	0.2514 ***
	(0.0117)	(0.0119)	(0.0163)	(0.0197)	(0.0127)	(0.0127)	(0.0134)	0.0137)	(0.0115)	(0.0117)	(0.0126)	(0.0239)
Health_condition	−0.2768 ***	−0.2776 ***	−0.2357 ***	−0.2143 ***	−0.1439 ***	−0.1503 ***	−0.1585 ***	−0.1300 ***	−0.2439 ***	−0.2439 ***	−0.2207 ***	−0.2454 ***
	(0.0272)	(0.0273)	(0.0430)	(0.0533)	(0.0271)	(0.0272)	(0.0374)	(0.0355)	(0.0270)	(0.0278)	(0.0333)	(0.0322)
VIF-value	1.13	1.12			1.12	1.1			1.09	1.08		
F-statistic	94.25 ***	93.3 ***			85.24 ***	81.49 ***			133.12 ***	128.68 ***		
Wald chi2			589.71 ***	470.08 ***			848.31 ***	843.36 ***			952.73 ***	817.76 ***
R2	0.2503	0.2469			0.3345	0.3292			0.1574	0.1627		
Observations	3471	3472	3394	3394	2853	2852	2792	2792	5548	5243	5097	5097

Note: (i) The standard errors are given in parenthesis. (ii) * $p < 0.1$, ** $p < 0.05$, and *** $p < 0.01$.

Somewhat surprisingly, the coefficients on farmland rental choices in columns (9)–(12) are not significant, indicating that farmland rental activity has no significant effect on off-farm income among both lessee and lessor households, which is consistent with the results of the existing literature [4,19]. For most lessor households, the renting out choice concerning their responsibility farmland may have had no significant impact on their existing income source. The study's sample featured a relatively high proportion of rural households participating in off-farm jobs (68.98% earned income from off-farm activities), and there was a remarkable gap between rental income (the average annual rent is 496.97 yuan/mu in our sample) received from lessee household(s) and wage or business income generated from off-farm employment. With relatively full off-farm employment, farmland renting out activity does not affect household off-farm income, as the rents received from the lessee unit are insignificant to the household's off-farm income, and thus the farmland rental's income impact on off-farm earnings was not evident. With regard to the total income (columns (1)–(4) in Table 4), the positive effect of farmland renting in activity on income is evidenced. At the same time, the renting out activity shows no significant signs of a positive effect on total income, implying only lessee households prominently gain benefits from the additional farm size.

In addition to our main variables of interest, the coefficients on household endowments, labor input, and demographic characteristics in the estimations are consistent with our expectations. It is interesting to note that we find a similar result with Jin and Jayne's evidence in rural Kenya [4], that the household head's education is not significantly associated with on-farm income. Education has a positive and significant relationship with total income, implying higher returns to education in off-farm jobs.

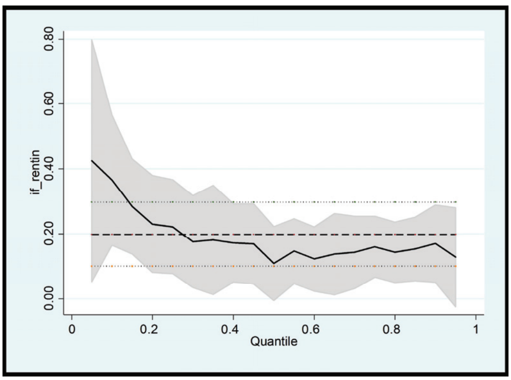
Next, we examine whether the income impact of farmland rental participation decisions varies across different income levels. Table 5 presents the results of quantile regressions. Based on the results presented in Table 5, we find the quantile regression results suggest that the OLS (mean) results mask the significant variation in returns across the income distribution. Based on the results presented in Table 5, we find that the coefficient on farmland renting in activity has a significant positive impact on total income at all income quantiles, which is consistent with benchmark results estimated with OLS regression. Notably, while farmland renting in activity increases household total income at all quantile levels, its income-increasing effect gets smaller in households at higher quantile levels (see Figure 3). This result indicates that the return to farmland renting in activity for low-income households is higher than that for high-income households. Hence, the inflow of farmland to low-income households is more sensitive about raising their income levels.

Table 5. Differential effects of farmland rental participation on rural household income.

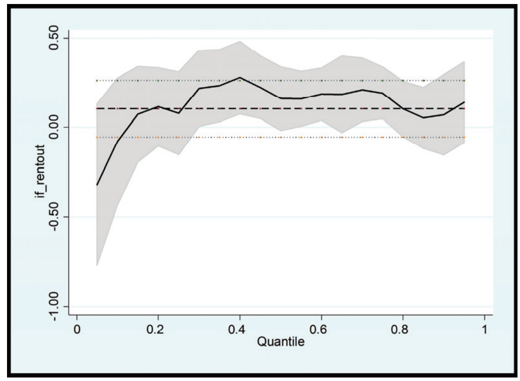
		Quantiles					Observations
		0.1	**0.25**	**0.5**	**0.75**	**0.9**	
Total income	*If_rentin*	0.3650 *** (0.0997)	0.2213 *** (0.0735)	0.1082 * (0.0666)	0.1082 *** (0.0666)	0.1692 *** (0.0563)	3471
	Pseudo R2	0.1271	0.1600	0.1623	0.1519	0.1475	
	If_rentout	−0.0797 (0.2157)	0.0777 (0.1644)	0.1597 * (0.0852)	0.1913 *** (0.0684)	0.0685 (0.1201)	3472
	Pseudo R2	0.1227	0.1574	0.1621	0.1514	0.1448	
On-farm income	*If_rentin*	0.1428 *** (0.1135)	0.2416 *** (0.0748)	0.3025 *** (0.0541)	0.3273 *** (0.0711)	0.3460 *** (0.0722)	2853
	Pseudo R2	0.1180	0.1634	0.2323	0.2607	0.2620	
	If_rentout	−0.1969 ** (0.1512)	−0.2773 ** (0.1133)	−0.1536 ** (0.0775)	−0.2023 *** (0.1380)	−0.1784 (0.1397)	2852
	Pseudo R2	0.1181	0.1625	0.2274	0.2548	0.2533	
Off-farm income	*If_rentin*	−0.0107 (0.0947)	−0.0669 (0.0946)	−0.1179 (0.0613)	−0.0194 (0.0500)	0.0155 (0.0574)	5548
	Pseudo R2	0.0952	0.1063	0.0987	0.0806	0.0775	
	If_rentout	−0.2392 (0.2259)	−0.1179 (0.0613)	0.0192 (0.0776)	0.1104 ** (0.0553)	0.1246 (0.0770)	5243
	Pseudo R2	0.0983	0.1092	0.1005	0.0833	0.0802	

Notes: (i) The above table only reports the estimation results of farmland rental participation variables. (ii) The standard errors are given in parenthesis. (iii)* $p < 0.1$, ** $p < 0.05$, and *** $p < 0.01$.

Meanwhile, we find the coefficient on farmland renting out activity is significantly positive with total income at middle and upper-middle income quantiles (0.5 and 0.75), while the OLS return to farmland renting out activity is not statistically significant. One likely explanation is that, compared with highest-income households who have largely left agricultural production and lowest-income households who are almost entirely dependent on farmland for agricultural production, middle and upper-middle income households are usually capable of both agricultural production and non-agricultural employment, and the off-income earned by the agricultural producer in middle and upper-middle income household who has the ability to participate in non-agricultural employment probably has a significant impact on their household income after renting out farmland. At the same time, we observe that the estimated coefficient of the impact of farmland renting out activity on off-farm income is significantly positive at the 75% quantile, revealing the positive effect of farmland renting out activity on increasing off-farm income for upper-middle income households.



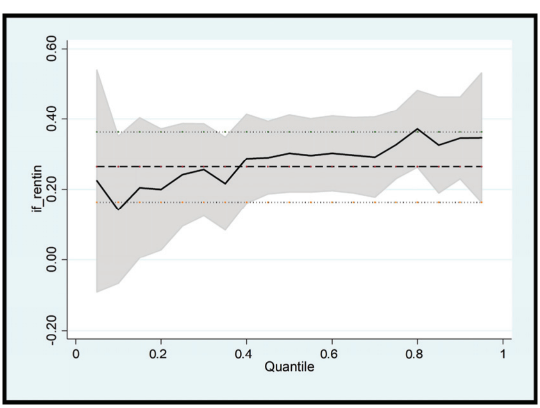
(**a**)



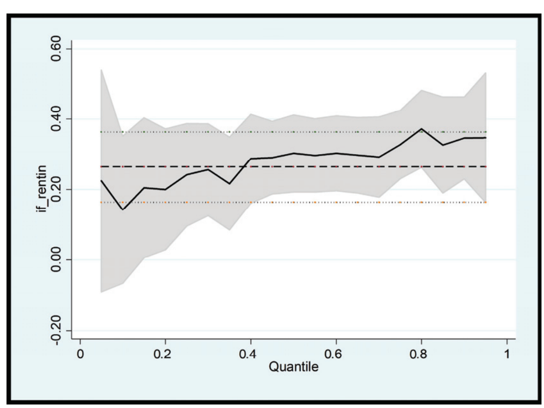
(**b**)

Figure 3. The effects of farmland renting in (**a**) and /renting out (**b**) on household total income across quantiles.

Regarding the on-farm income, the estimated coefficients describing the effect of farmland renting in activity on farm income are significantly positive at all farm income quantiles, and the return on farm income to farmland renting in activity increases with the rise of farm income level (see Figure 4). These estimates confirm the previous finding that rural households with relatively high farm income are more likely to achieve economies of scale and therefore seem to benefit more from enlarging additional land. The coefficient on renting out farmland is negative and statistically significant at 0.1, 0.25, 0.5, and 0.75 quantiles. Possible reasons why renting out farmland is not substantial for households with the highest farm income are that those households are mainly intensive farming producers, and they mostly do not rent their farmland to others.



(**a**)



(**b**)

Figure 4. The effects of farmland renting in (**a**)/renting out (**b**) on household on-farm income across quantiles.

Furthermore, in this case, despite the fact that the estimated coefficient of farmland impact of renting out activity on off-farm income is significant at the 75% quantile, the results show farmland rental participation activities have no significant effects on household off-farm income at all quantiles, which agrees with OLS results in Table 4.

5.2. The Impacts of Rental Area and Agricultural Productivity

Regarding lessee households, farmland rent in participation has no significant impact on household off-farm income. Thus, this part of the study mainly evaluated lessee households' on-farm income and total income impacts based on the renting in area and farming efficiency. The result (Table 6, column 1) confirms the significant positive effect of the renting in area on a lessee households' on-farm income. This finding indicates that increasing farmland production elements' input can contribute to agricultural yield and suggests that lessee households with increased farm size could receive chances to achieve scale economies and thus obtain more income. Meanwhile, results also indicate significant positive effects of agricultural efficiency on household on-farm income. Column 2 further illustrates the result of the on-farm income impact of the interaction item between the renting in scale and agricultural efficiency. The result also shows that the interaction item had a significant positive effect on household on-farm income variables, thus suggesting that increasing the scale of area rented or household agricultural efficiency could boost each other's positive impact on on-farm income. This result also implies that highly productive rural households benefited more from renting in farmland. Similarly, households with additional rentable farmland earned more on-farm income when their productivity improved. Since farmland renting in participation and the rented area are not significantly associated with off-farm income and have significant positive relationships with total income, this suggests higher returns to increasing farm size through the rental market for lessee households.

Table 6. The effects of the rented in area and agricultural productivity on household on-farm income for lessee households.

Variable Name	On-Farm Income		Total Income	
	(1)	(2)	(3)	(4)
In_area	0.0131 *** (0.0019)	0.0097 *** (0.0017)	0.0060 *** (0.0017)	0.0031 *** (0.0024)
Agr_eff	0.0001 *** (4.72×10^{-5})	0.0001 *** (3.9×10^{-5})	7.75×10^{-5} *** (2.75×10^{-5})	5.50×10^{-5} *** (1.94×10^{-5})
*In_area*Agr_eff*		1.5E-05 *** (4.94×10^{-6})		1.49×10^{-5} *** (4.67E-06)
Farmland_area	0.0321 *** (0.0040)	0.0315 *** (0.0040)	0.0131 *** (0.0044)	0.0130 *** (0.0044)
Land_quality	0.0783 * (0.0436)	0.07569 * (0.0433)	0.1167 *** (0.0402)	0.1154 *** (0.0400)
Agr_labor	0.0849 *** (0.0600)	0.0909 *** (0.0602)	−0.0878 *** (0.0542)	−0.0834 *** (0.0542)
Agr_input	2.33×10^{-5} *** (5.09×10^{-6})	2.1×10^{-5} *** (5.29×10^{-6})	2.76×10^{-6} *** (4.93×10^{-6})	-1.26×10^{-6} *** (5.46×10^{-6})
Head_age	−0.0119 *** (0.0043)	−0.0116 *** (0.0043)	−0.0131 *** (0.0042)	−0.0129 *** (0.0042)
Head_edu	0.0932 * (0.0515)	0.0875 * (0.0513)	0.1231 ** (0.0496)	0.1198 ** (0.0495)
Head_gender	0.0360 (0.1659)	0.0226 (0.1648)	0.0155 (0.1566)	0.0044 (0.1552)
If_official	0.3139 ** (0.1405)	0.3024 ** (0.1444)	0.2201 (0.1515)	0.2107 (0.1518)
Family size	−0.0510 *** (0.0294)	−0.0488 * (0.0291)	0.1988 *** (0.0217)	0.2014 *** (0.0217)
Health_condition	−0.2179 *** (0.0639)	−0.2221 *** (0.0633)	−0.2773 *** (0.0577)	−0.2792 *** (0.0572)
Constant	9.1777 *** (0.4992)	9.2139 *** (0.4981)	9.9176 *** (0.4517)	9.9395 *** (0.4480)
VIF	1.16	1.27	1.2	1.31
F- statistic	44.62 ***	43.84 ***	26.2 ***	26.39 ***
R^2	0.4096	0.4163	0.2613	0.2684
Observations	630	630	706	706

Notes: (i) The standard errors are given in parenthesis. (ii) * $p < 0.1$, ** $p < 0.05$, and *** $p < 0.01$. (iii) The number of valid samples reduced due to the analysis on lessee households only.

For lessor households, the farmland renting out activity was initially examined to reduce household on-farm income, while its impact on off-farm income was limited. This section further explores the impact of farmland area rented out and agricultural productive efficiency on household on-farm income, and evaluates the interaction effect between farmland outflow scale and household non-agricultural working hours on off-farm income to identify whether the outflow area of farmland regulates the income impact from household off-farm labor volumes. Based on the estimated results (Table 7, column 1), the coefficients on the rented out area and agricultural productivity are both significant, suggesting household on-farm income declined significantly with the increase in an area rented out and household agricultural productivity still had a positive impact on farm income. Column 2 presents results from the interaction item of the rented out area and agricultural productivity, which is positively associated with household on-farm income, implying that improving household agricultural productivity could slightly offset the negative farm income impact from reduced farmland area. Columns 3 and 4 display the estimated results of the off-farm income impact from the rented out farmland area and off-farm working hours. The coefficients on the rented out area and its cross terms with wage hours and business hours in columns (3) and (4) are not significant, suggesting that the rented out area and its interaction effect with off-farm working hours input had no significant impact on household off-farm income. This is probably because lessor households usually engaged in non-agricultural jobs or discontinued on-farm production for the agricultural labor shortage and thus the household non-agricultural employment capacity released by renting out farmland was limited, so the impact of renting out scale on off-farm income was not significant.

Table 7. The effects of the rented out area and agricultural productivity on household on-farm income for lessor households.

	On-Farm Income		**Off-Farm Income**	
	(1)	**(2)**	**(3)**	**(4)**
Out_area	−0.0031 ** (0.0268)	−0.0296 ** (0.0270)	0.0138 (0.0093)	0.0130 (0.0101)
Agr_eff	6.10×10^{-5} *** (1.32×10^{-5})	4.48×10^{-5} *** (3.04×10^{-5})		
*Out_area*Agr_eff*		3.56×10^{-5} *** (1.14×10^{-5})		
Bus_hour			0.0096 *** (0.0261)	0.0161 *** (0.0355)
Wage_hour			0.1060 *** (0.0142)	0.1047 *** (0.0193)
*Out_area*Bus_hour*				0.0015 (0.0036)
*Out_area*Wage_hour*				0.0002 (0.0018)
Farmland_area	0.0107 (0.0186)	0.0245 (0.0194)		
Land_quality	0.0242 (0.0899)	0.0428 (0.0912)		
Agr_labor	−0.0816 (0.0992)	−0.0915 (0.1000)		
Agr_input	6.27×10^{-5} *** (1.35×10^{-5})	6.14×10^{-5} *** (1.17×10^{-5})		
Head_age	−0.0126 (0.0088)	−0.0109 (0.0086)	−0.0015 (0.0072)	−0.0017 (0.0074)
Head_edu	0.0086 (0.1051)	0.0015 (0.1045)	0.0878 (0.0798)	0.0888 (0.0801)

Table 7. *Cont.*

	On-Farm Income		Off-Farm Income	
	(1)	**(2)**	**(3)**	**(4)**
Head_gender	0.1743 (0.2719)	0.1580 (0.2604)	0.8537 (0.3002)	0.8525 (0.3003)
If_official	−0.3656 (0.2444)	−0.3866 (0.2459)	−0.1186 (0.2852)	−0.1197 (0.2869)
Familysize	0.0625 (0.0519)	0.0756 (0.0501)	0.2132 *** (0.0414)	0.2134 *** (0.0415)
Health_condition	−0.0995 (0.1114)	−0.0958 0.1096)	−0.0916 (0.0972)	−0.0890 (0.0980)
Constant	9.1132 *** (0.7758)	8.9085 *** (0.7457)	9.2033 *** (0.7417)	9.2059 *** (0.7504)
VIF	1.35	1.7	1.11	1.39
F-value	28.40 ***	36.34 ***	15.59 ***	14.35 ***
R^2	0.3385	0.3731	0.1897	0.1899
Observations	158	158	485	485

Notes: (i) The standard errors are given in parenthesis. (ii) ** $p < 0.05$, *** $p < 0.01$. (iii) The number of valid samples reduced due to the analysis on lessor households only.

6. Discussion

Land reform has been regarded as the most effective remedy for reducing income inequality [74]. Several rounds of market-oriented rural land reform foster the development of the farmland rental market by encouraging farmland rental activities among farm units, which profoundly influences rural households' livelihood strategies and income earnings. The study results suggest that farmland rental participation activity significantly affected Chinese rural households' on-farm income. Renting in farmland significantly and positively affected lessee households' on-farm income and household total income, which agrees with existing findings in previous studies [4,19,20]. Meanwhile, the increase in farmland renting in area and household agricultural productivity directly improve their on-farm income and strengthened each other's role in promoting farm income. Essentially, most lessee tenants in rural China have the necessary conditions to achieve intensive specialized production (see Figure 3). We also find the return on household's on-farm income to farmland renting in increases with the rise of farm income level through QR regression. Thus, our study's evidence supports that, for high-productivity specialized households with relatively high farm income levels, expanding farm size was more output-sensitive and, therefore, benefited more from increasing farm size.

Additionally, the study results show farmland outflow could significantly reduce household on-farm income, while it had no significant impact on off-farm income on average. These results are consistent with Zhang et al. [19], who found that renting out land fails to improve lessor households' off-farm income. Furthermore, the scale of farmland outflow's indirect effect on household off-farm income was not evident; this shows that land outflow has little impact on household labor force distribution. Rural households with stable off-farm employment opportunities are often more inclined to rent out their farmland [43,52,79,80]. Accordingly, within lessor households with experience in off-farm employment, young and middle-aged males, who form the dominant labor force within such households, usually migrate to cities or suburbs to find off-farm work. Even when farmland is not rented out, left-behind elderly or women stay at home to do farm work [81–83], thus, the potential non-agricultural labor force released from farmland rental becomes limited. At the same time, study findings from QR regression results initially provide evidence supporting for those lowest and middle and upper-middle income households with both agricultural and non-agricultural employability, and farmland renting out has potential contribution in improving their off-farm earnings. For those households with non-agricultural employability while also having no work experience in any off-farm sectors, off-farm income may depend positively on farmland renting out activities, and thus governments could promote off-farm employment by organizing land cooperatives to stimulate their willingness to rent out land and enhance livelihood diversities [51].

Currently, along with the market-oriented reforms in China's agricultural land property rights system, the gradual functioning farmland rental market has also challenged traditional household production patterns. It has taken on a more important role in improving agricultural productivity and accelerating agricultural modernization processes. One study [8] suggested that farmland productivity would increase to about 60% through farmland rental in rural China. This productivity improvement would translate into increased welfare for lessor households by facilitating occupational diversifications. In this case, expanding farmland production scale could be a realistic choice for achieving agricultural modernization in China. Indeed, most of the specialized farming units were cultivated with guidance and support by local governments. Even the specialized farming units were regarded as major bodies for achieving agricultural modernization in China, current farm sector development is still dominated by autarkical small-scale farming, with farmland fragmentation as the fundamental characteristic of agricultural production [34]. Along with TPRS reform, the central government promoted various reform policies, such as establishing rural land trading canter, promoting rural collective land registration, granting rental subsidies to leaseholders, etc., which jointly accelerated the development of farmland rental markets. However, these policies are potentially more beneficial for intensive specialized units rather than smallholders. With government support, the number of smallholders renting their responsibility farmland to agricultural enterprises and cooperatives has increased, while in turn, the possibility of mutual leasing of farmland among smallholders would decrease. This potential for increasingly uneven farmland distribution could lead to overall inequality in terms of income and benefits [18]. Consequently, the release of non-agricultural labor force should be undertaken simultaneously with productivity improvement in intensive farming producers. In this regard, it is necessary to prevent a large number of farmers from becoming unemployed subjects with no off-farm jobs and no farmland to support their fundamental livelihoods.

7. Conclusions and Policy Implications

The rural land rental market plays an increasingly important role in the agricultural transformation of the current period in China. This paper investigated the impact of farmland rentals on household income in rural China. Even though we chose only China as our case study, this discussion issue is relevant for a wide range of transition countries, including those in Southern Africa, Southeast Asia, and Eastern Europe, which are dominated by smallholder farms and liberalized land exchange constraints because of land reforms or farm restructuring. This paper's major contribution was exploring mechanisms underlying farmland rental markets' effect on households' earnings by further investigating the relative roles of farmland rental area and household agricultural productivity.

This paper's results showed that farmland rental participation affected household income significantly—that is, lessees' renting of farmland positively increased their households' on-farm and total income; furthermore, this on-farm income positively depended on renting scale and household agricultural productivity, while renting out farmland fails to improve lessor households' off-farm and total income on average. With regard to income differences across quantiles, we found that households with high on-farm income are more sensitive about enlarging farm size by renting farmland, and households with middle and upper-middle off-income may benefit more from renting out their farmland. Meanwhile, the positive farm income impact from the interaction relationship between enlarged farm size and improved agricultural ability indicates that highly productive rural households could benefit more by expanding their farm size through the farmland rental market. For lessor households, our results imply that farmland renting out may limitedly affect their labor force distribution since renting out farmland was more likely to factor in decision making among rural households with stable off-farm employment but less agricultural labor. Simultaneously, since households that have high return non-agricultural employment are not dependent on farmland for their livelihood, farmland renting out forms an insignificant proportion of such households' total and off-farm income.

Our relevant policy-related findings were as follows. Within the collective-owned rural land system, developing farmland rental market—a process accelerated by TPRS reform—contributed toward land reallocation among farming households. Consequently, lessee households' income increased significantly through farm size enlargement; households with non-agricultural employability are able to enhance their livelihood diversities, and thus, income gaps among farmers could largely decrease. However, some Chinese government interventions still affect the imperfect farmland rental market, and extensive farmland was rented out to large-scale operators through rental cooperative organizations. Whether the farmland rental market provides equal access opportunities for smallholders and reduces income inequality among all farm units remains to be seen. Despite these imperfections and uncertainties, our findings suggest that a well-functioning farmland rental market in rural China can play a positive role in achieving farming efficiency and poverty reduction. Therefore, policies addressing the twin goals of efficiency improvement and income increase should be properly oriented. However, various forms of moderate scale production should be developed vigorously, and large-scale farm operators should receive leading roles in modern agricultural development. Various government-launched service organizations, including established land transfer centers promoting farmland consolidation, are still essential for supporting highly efficient large farms in enlarging farm size. Nevertheless, to secure smallholders' share of land reform benefits, related policies should provide each rural household with equal opportunities to engage in farmland rental activities based on their land and labor endowments. For households with the lowest off-farm income and for rural households close to the poverty line, improving their development ability and resource use efficiency is essential for maintaining their sustainable livelihood development [84]. In this case, it is effective and valuable to actively organize farmland rental cooperatives to aid households having fewer off-farm employment opportunities to engage in farmland rental and thus enhance their off-farm livelihood diversities.

Several research prospects still need to be explored based on our findings. First, as there is internal regional heterogeneity in China's farmland rental market, for example, the transaction cost of farmland transfer is higher in less-developed areas than in developed areas [85], which may lead to geographical differences in the income effects of farmland transfer on rural households and could be further investigated in future studies. Second, it is also worth discussing how market interference by local governments (the information is challenging to collect by national survey) is fair for smallholders to access the farmland rental market and whether this helps narrow income inequality among farmers.

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Note

[1] This figure was announced in the Ministry of Agriculture and Rural Affairs of PRC's reply to proposal No. 2292 of the third session of the 13th National People's Congress (at http://www.moa.gov.cn/govpublic/FZJHS/202011/t20201117_6356403.htm, November 2020).

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Article

Impact of Grain Subsidy Reform on the Land Use of Smallholder Farms: Evidence from Huang-Huai-Hai Plain in China

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Abstract: Smallholder farms have played an essential role in agricultural production and food security. In order to increase farm size, the Chinese government announced a reform of the grain subsidy program in 2015. Under the reform, 20% of the aggregate input subsidy, as well as the pilot subsidy to large-scale farmers and the incremental part of the agricultural support and protection subsidy budget, were used to support increasing farm size. This study evaluated the impact of China's grain subsidy reform on the land use of smallholder farms to investigate whether the reform achieved its goal. Based on 2063 samples obtained from the 2013–2015 Survey for Agriculture and Village Economy data in Huang-Huai-Hai Plain, we conducted a difference-in-difference model to solve the problem of missing counterfactual states in policy evaluation. Farms from Henan and Shandong were assigned to the treatment group, and farms from Hebei were assigned to the control group. The results revealed that the average treatment effect on the treated of the impact of the grain subsidy reform on the wheat-sown area was −25% (0.10 ha). Furthermore, there was heterogeneity in regard to the subsidy reform effects in different sown-area groups. The reform had the most significant impact on the smallest farmers. We also found that China's grain subsidy reform had a significant and positive effect on the amount of outflow land area, while the impact of subsidy reform on land tenure was insignificant. Our findings suggest that while encouraging large-scale farms, it is necessary to take into account farmers' small-scale operations and gradually promote the transformation of small-scale operations to large-scale operations. The Chinese government should strengthen the supervision of land use to achieve the goal of ensuring food security.

Keywords: agriculture subsidy program; land use; farm size; difference-in-difference

1. Introduction

Food security is the 2nd Sustainable Development Goal (SDG2) and a key objective of the Chinese agricultural policy [1,2]. Smallholder farms have played an essential role in agricultural production and food security, especially in Asian countries [3–5]. In China, the average farm size is only 0.52 ha, and nearly 98% of farms are smaller than 2 ha [3,6]. Recently, several efforts have been undertaken by the Chinese government to encourage the farms to expand to increase farm output efficiency, reduce production costs, and reduce the use of agricultural chemicals [7–11].

Previous studies have shown that subsidy programs, e.g., direct payments, are efficient tools to achieve policy goals [12–15]. Since the commencement of the country's first grain subsidy program in 2004, China's grain output has increased dramatically, reaching 663.84 million tons in 2019, with an annual growth rate of 2.3% [16]. Meanwhile, China's Producer Support Estimate (PSE) has increased from 170.9 billion CNY in 2004 to 1.4 trillion CNY in 2016 [17].

China launched its grain subsidy program in 2004 to increase grain production and farmers' incomes [18–20]. The program consisted of direct grain subsidy, quality seed subsidy, and machinery subsidy [18,21,22]. Later in 2006, the aggregate input subsidy was introduced to the grain subsidy program when fertilizer and fuel prices rose rapidly [18,19,21,23]. The direct grain subsidy, the quality seed subsidy, and the aggregate input subsidy (also known as the "three subsidies") were wired to farmers' bank accounts mainly based on the grain-sown areas [21,23]. This machinery subsidy was only available to those who purchased medium or large machines, and approximately 30–50% of the subsidy value was deducted from the cost of these machines [23]. The subsidy amount was 1425 CNY/ha in 2012, and an average Chinese farm could only receive 741 CNY/ha, about 6.7% of its annual income [23].

In 2015, the Ministry of Finance (MOF) and the Ministry of Agriculture (MOA) announced a reform of the grain subsidy program through combining the direct grain subsidy, the quality seed subsidy, and the aggregate input subsidy into an "agricultural support and protection subsidy". To actively and steadily promote the grain subsidy reform, the MOF and MOA selected Anhui, Shandong, Hunan, Sichuan, and Zhejiang as the reform pilot provinces in 2015 [24]. The Henan province, however, also reformed the grain subsidy based on the announcement issued by the MOF and MOA in 2015 [25]. Then, the reform has been implemented nationwide since 2016. The reform aims were set to improve the accuracy of subsidy, strengthen the protection of arable land, and increase farm size [24]. Furthermore, the agricultural support and protection subsidy is still a planted-area-based subsidy based on hectares planted to grain [26]. In particular, Shandong Province, one of the pilot provinces, addressed that the subsidy would be paid according to the area of wheat sown [27].

Under the reform, 20% of the aggregate input subsidy, as well as the pilot subsidy to large-scale farmers and the incremental part of the agricultural support and protection subsidy budget, were used to support increasing farm size. Furthermore, the subsidy targets included large-scale farms, large-scale family farms, farmer cooperatives, and agricultural socialization service organizations. The government also announced a slogan; whoever has a higher grain production would receive priority support of subsidy fund. Additionally, 80% of the aggregate input subsidy, as well as the direct grain subsidy and the quality seed subsidy were used to protect arable land and increase land productivity. In 2016, the total amount of "agricultural support and protection subsidy" reached 144.2 billion CNY, including 23.8 billion CNY to increase farm size [28].

Moreover, as designed by the policymakers, smallholder farms would receive fewer subsidies, while subsidy amounts for large-scale and cooperative farming would increase. Consequently, the reform may have two opposing impact pathways. Firstly, smallholder farms would increase their farm size to receive more subsidies. Secondly, smallholders might transfer their lands to large-scale farmers or cooperatives so as to decrease or terminate their grain production.

Previous studies on the China's grain subsidy effects mainly focused on production [29–32], migration [33,34], effectiveness [26,35], and welfare [18,29,32,36]. Some studies also shed light on the relationship between China's agricultural subsidy and land use. For instance, Yi et al. (2015) concluded that the grain subsidy program had a positive effect on grain-sown areas [23]. Zou et al. (2020) found that the grain subsidy had a significant and positive effect on both leasing out and leasing in farmland in rural China [37]. Guo et al. (2021) concluded that an increase in soybean producer subsidy would encourage farmers to allocate more land for soybean planting [38]. Additionally, since grain subsidies might increase land tenure [39], the grain subsidies were paid mostly to the land contractor instead of the operator [31,37], and farm size was found to have a significantly negative effect on land tenure [39]. Huang et al. (2011) demonstrated that the grain subsidy policy did not affect their grain production decisions [31]. However, to our knowledge, previous studies have rarely empirically explored whether China's grain subsidy reform achieved its goal to increase farm size. This study contributes to the literature by providing evidence on the relationship between the subsidy reform and the land use of smallholder farms and reveals the impact pathways of the reform. Our results also have important policy implications to further improve China's grain subsidy programs.

The main challenge in empirically evaluating policy impacts is to determine how to address missing counterfactual states, because we observe what happens to them with treatment, but we cannot observe what would have happened without treatment [40]. In practice, propensity score matching (PSM) [41–43], regression discontinuity designs (RDD) [44,45], and difference-in-difference (DID) [46–51] are the most common approaches used for counterfactual analysis. However, PSM is mainly used to correct selection bias [41], and RDD can be applied when policy leads to the cut-off for key explanatory variables [45]. In this study, since the subsidy reform was exogenously issued by the government and covered each farm in the pilot provinces, selection bias would not occur, and the reform would not bring any cut-offs. We thus adopted the DID approach to evaluate the impacts of China's grain subsidy reform on the land use of smallholder farms, the heterogeneity across different farm-size groups, and the potential impact pathways of the reform.

2. Materials and Methods

2.1. Study Area

Huang-Huai-Hai Plain is one of the most productive grain belts, especially winter wheat growing areas in China (Figure 1) [52,53]. In 2019, Huang-Huai-Hai Plain produced 23.8% of China's grain and 58.1% of China's wheat [16]. Furthermore, two pilot provinces implemented a subsidy reform in 2015, i.e., Shandong and Henan, located at the Huang-Huai-Hai Plain. To evaluate the impact of China's grain subsidy reform, farms should be assigned either to the treatment group or to the control group. First, farms from Henan and Shandong were subjected to the reform, and were therefore assigned to the treatment group. Second, we selected the farms in the Hebei Province as the control group since the province lies on the Huang-Huai-Hai Plain, but has not reformed the grain subsidy until 2016.

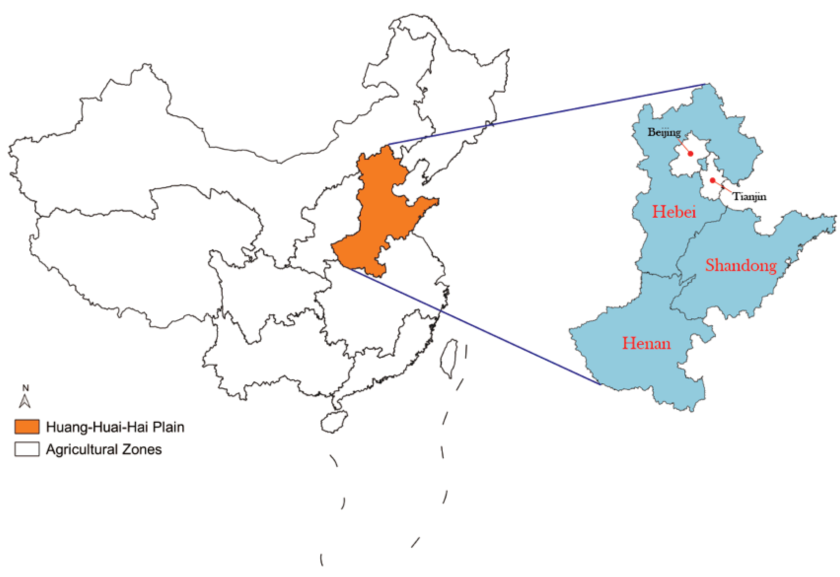

Figure 1. The geographical location of the study areas.

2.2. Experimental Design

2.2.1. Empirical Method

This study employs a difference-in-difference (DID) approach to evaluate the impacts of China's grain subsidy reform on the land use of smallholder farms. As shown in Figure 2, the first difference is the difference between post- and pre-treatment in the treatment group ($A2 - A1$), and the second difference is the difference between post- and pre-treatment in the control group ($B2 - B1$). The impact of treatment on the outcome of interest is $(A2 - A1) - (B2 - B1)$.

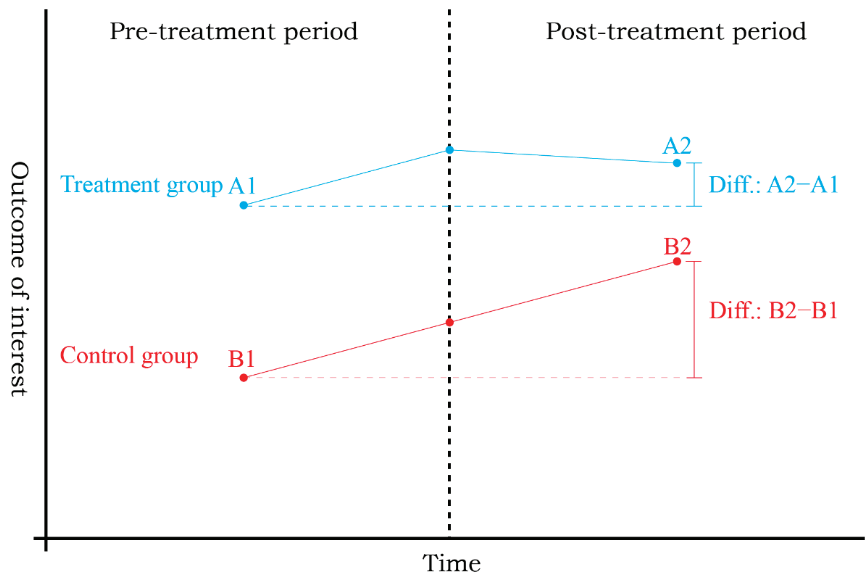

Figure 2. Conceptual illustration of the DID approach.

Let Y_{it} be the outcome of interest for farm i at time t. The naive difference-in-differences estimator is described as the following regression:

$$y_{it} = \alpha + \beta(D_i \times T_t) + \gamma D_i + \delta T_t + \varepsilon_{it} \tag{1}$$

where D_i is an indicator variable equal to 1 if farm i has been exposed to the treatment (e.g., policy reform) and 0 otherwise; T_t is a time-specific component; $t = 0$ if the population is observed in a pre-treatment period, and $t = 1$ in a post-treatment period; α is a constant; β captures the average treatment effect on the treated (ATET), which is $(A2 - A1) - (B2 - B1)$ in Figure 2 and the focus of policy evaluation; γ and δ are other parameters to be estimated; ε_{it} represents the random error item. Therefore, the DID procedure removed a large degree of the potential for biases attributable to unobservable heterogeneity and omitted variables [46,54].

In our study, the outcome variable is the wheat-sown areas (WA_{it}) due to the following two reasons. First, the subsidy was allocated based on the wheat-sown areas in the Shandong province [27], which indicated that farms could receive more subsidies if they enlarged their wheat-sown areas. Second, since the reform announcement was issued in May 2015 by the central government, in June 2015 by the Shandong province, and in August 2015 by the Henan province, respectively, only winter crops (i.e., winter wheat in the Huang-Huai-Hai Plain) could be affected by the reform [24,25,27]. Further, we used the logarithm form of wheat-sown areas to obtain the percentage changes in wheat-sown areas. Additionally, since the subsidy reform was piloted in 2015 and implemented nationwide in 2016, we denoted $t = 0$ if $T < 2015$, and $t = 1$ if $T = 2015$. We also added a group of control variables (x_{itj}) that affect wheat-sown area to Equation (1). Based on the previous literature, the x_{itj} include labor and tractor input, land tenure, and individual characteristics of the household heads (HHs), such as the age, years of education, and agricultural training. Thus, Equation (1) can be revealed as the following:

$$\ln WA_{it} = \alpha + \beta(D_i \times T_t) + \gamma D_i + \delta T_t + \Sigma_{j=1}^{n} \gamma_j x_{itj} + \varepsilon_{it} \quad (2)$$

where n is the number of the control variables and γ_j are the parameters to be estimated. One of the main assumptions to estimate the DID model is parallel trends [55]. Under the parallel trends assumption, trends in outcomes between the treatment and control groups are the same prior to the implementation of the subsidy reform [46].

2.2.2. Data Collection

Data used in this study were obtained from the 2013–2015 Survey for Agriculture and Village Economy (SAVE), which is an annual rural household survey conducted by the Institute of Agricultural Economics and Development (IAED), the Chinese Academy of Agricultural Sciences (CAAS) [43]. We select an unbalanced panel sample from 93 villages in 9 counties in Hebei (the counties of Pingshan, Luannan, and Qiu), Shandong (the counties of Qixia, Shouguang, and Gaotang), and Henan (the counties of Fan, Xuchang, and Queshan) provinces (Figure 3).

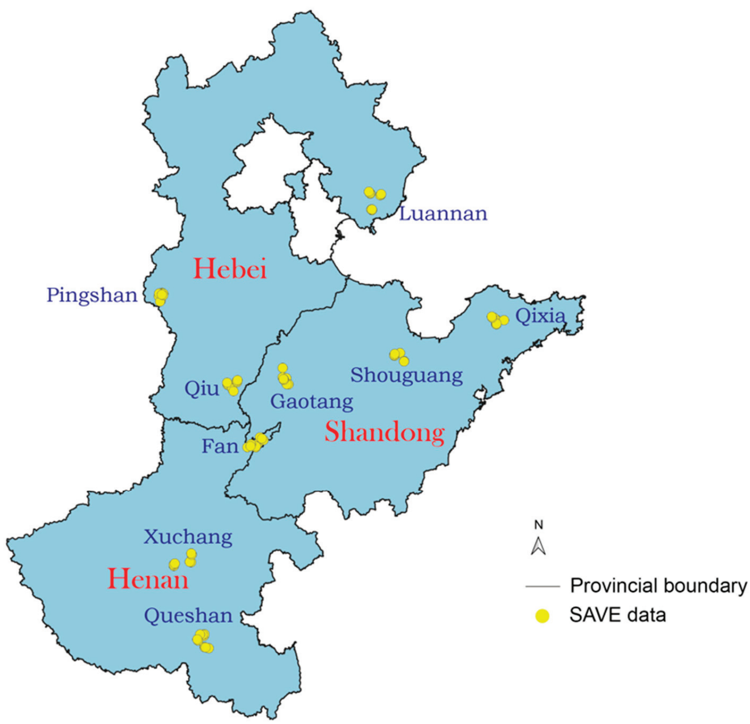

Figure 3. The geographical location of the samples.

Before estimation, the data were processed as follows. (1) The variables related to price were processed using the national Consumer Price Index (CPI, 2012 = 100) to eliminate the effect of inflation. (2) Only farms with a wheat-sown area greater than 0 and less than 2 ha (the threshold of smallholder farm) were kept. (3) To reflect the opportunity cost of land transfer, missing values for land tenure were replaced with the provincial median in the same year. (4) To exclude the effect of machinery subsidy, the households that purchased agricultural machinery in the survey year were removed. After data processing, 2063 valid samples were retained, and 1550 were treated (Table A1).

3. Results

3.1. Descriptive Analysis

As shown in Table 1, the average wheat-sown area in the sample regions was only 0.39 ha. The average subsidy farmer received and land tenure were 1847.28 CNY/ha and 2742.87 CNY/ha, respectively. Further, since labor is still essential in China's wheat production, the average labor input reached 71.38 days/ha, while only 34% of farms own at least one tractor. In terms of individual characteristics of the household heads (HHs), most wheat farmers were aged, less-educated, and none-trained. The average age reached 52.51, while the average years of education of wheat farmers were only 7.83. Lastly, only 34% of wheat farmers in the survey received agricultural training.

Table 1. Summary statistics of variables.

Variable	Mean	SD	MAX	MIN
Panel A: All farms				
WA: Wheat-sown area (ha)	0.39	0.24	2.00	0.03
SUB: Subsidy (CNY/ha)	1847.28	517.47	4425.00	719.82
LAND: Land tenure (CNY/ha)	2742.87	313.97	7037.30	718.09
LB: Labor input (Days/ha)	71.38	45.25	242.92	18.75
TRAC: Tractor ownership (1 = Y, 0 = N)	0.37	0.48	1.00	0.00
AGE: Age of HH	52.51	10.62	88.00	19.00
EDU: Education of HH (Years)	7.83	2.61	16.00	0.00
AGT: Agricultural training (1 = Y, 0 = N)	0.34	0.47	1.00	0.00
Number of observations (N)	2063			
Panel B: Farms in the treatment group (Henan and Shandong)				
WA: Wheat-sown area (ha)	0.40	0.25	2.00	0.03
SUB: Subsidy (CNY/ha)	1795.73	413.67	4125.00	720.00
LAND: Land tenure (CNY/ha)	2731.28	319.26	7037.30	718.09
LB: Labor input (Days/ha)	73.23	48.71	242.92	18.75
TRAC: Tractor ownership (1 = Y, 0 = N)	0.33	0.47	1.00	0.00
AGE: Age of HH	52.93	10.41	88.00	19.00
EDU: Education of HH (Years)	7.71	2.80	16.00	0.00
AGT: Agricultural training (1 = Y, 0 = N)	0.32	0.47	1.00	0.00
Number of observations (N)	1550			
Panel C: Farms in the control group (Hebei)				
WA: Wheat-sown area (ha)	0.34	0.20	1.67	0.04
SUB: Subsidy (CNY/ha)	2003.02	726.87	4425.00	719.82
LAND: Land tenure (CNY/ha)	2777.87	294.95	5654.27	807.75
LB: Labor input (Days/ha)	65.79	32.02	240.00	18.75
TRAC: Tractor ownership (1 = Y, 0 = N)	0.48	0.50	1.00	0.00
AGE: Age of HH	51.26	11.15	79.00	25.00
EDU: Education of HH (Years)	8.19	1.90	12.00	0.00
AGT: Agricultural training (1 = Y, 0 = N)	0.40	0.49	1.00	0.00
Number of observations (N)	513			

Compared with the control group, farms in the treatment group had significant characteristics (Table 2). First, the wheat-sown area of farms in the treatment group was 0.07 ha (or 19.5%) larger than that of the farms in the control group. Second, subsidy and land tenure per area in the treatment group were 207.29 CNY/ha (or 10.3%) and 46.59 CNY/ha (or 1.7%) less of that of the control group, respectively. Third, farms in the treatment group tended to input more labor other than buy tractors. Fourth, HHs in the treatment group were significantly older than those of the control group, while the education level and agricultural training participation of HHs was significantly less than those of the control group.

Table 2. Differences of variables between the treatment and control groups.

Variable	Diff. in Means $\text{Mean}_T - \text{Mean}_C$	Diff.% $(\text{Mean}_T - \text{Mean}_C)/\text{Mean}_T$
WA: Wheat-sown area (ha)	0.07 *	19.4%
SUB: Subsidy (CNY/ha)	−207.29 *	−10.3%
LAND: Land tenure (CNY/ha)	−46.59 *	−1.7%
LB: Labor input (Days/ha)	7.44 *	11.3%
TRAC: Tractor ownership (1 = Y, 0 = N)	−0.15 *	−31.3%
AGE: Age of HH	1.67 *	3.3%
EDU: Education of HH (Years)	−0.48 *	−5.9%
AGT: Agricultural training (1 = Y, 0 = N)	−0.08 *	−20.0%

Notes: Mean_T and Mean_C indicates means in the treatment group and control group, respectively; * $p < 0.05$ based on the *t* test.

After the subsidy reform (Table 3), wheat farms did not significantly change their wheat-sown area, although the subsidy was 62.96 CNY/ha (or 3.3%) less than before, and the land tenure per area was 343.95 CNY/ha (or 13.1%) more than before. Furthermore, compared with the pre-treatment group, farms significantly decreased their labor input but increased their machine input in wheat production.

Table 3. Differences of variables between the pre- and post-treatment groups.

Variable	Diff. in Means $\text{Mean}_{Pt} - \text{Mean}_{Pr}$	Diff.% $(\text{Mean}_{Pt} - \text{Mean}_{Pr})/\text{Mean}_{Pr}$
WA: Wheat-sown area (ha)	0.06	15.8%
SUB: Subsidy (CNY/ha)	−62.96 *	−3.3%
LAND: Land tenure (CNY/ha)	343.95 *	13.1%
LB: Labor input (Days/ha)	−12.86 *	−17.0%
TRAC: Tractor ownership (1 = Y, 0 = N)	0.02 *	5.6%
AGE: Age of HH	0.69	1.3%
EDU: Education of HH (Years)	0.08	1.0
AGT: Agricultural training (1 = Y, 0 = N)	−0.11	−29.2

Notes: Mean_{Pt} and Mean_{Pr} indicates means in the post- and pre-treatment groups, respectively; * $p < 0.05$ based on the *t* test.

3.2. DID Results

We empirically analyzed the impact of the grain subsidy reform on the wheat-sown area based on a DID approach. Since the samples are clustered (Figure 3), we applied a clustered ordinary least squares (OLS) estimation strategy to obtaining robust variance estimates. Based on Equations (1) and (2), we added the control variables step by step and arranged the estimation results in Table 4.

The most important finding of our results is that China's grain subsidy reform significantly, but negatively, affects smallholder farms' wheat-sown area in the Huang-Huai-Hai Plain. Controlling the characteristic variables (columns 3 (DID3) in Table 4), the ATET of the impact of the grain subsidy reform on the wheat-sown area was −25%. It indicates that after the grain subsidy reform, a smallholder farm would reduce 25% (0.10 ha) of its wheat-sown area. Further, it is not a surprise that labor input negatively affects the wheat-sown area, while tractor ownership positively affects the wheat-sown area. The relationship between the age of HHs and wheat-sown area shows an inverse "U-shape", while there is a "U-shape" relationship between the education level of HHs and wheat-sown area. Agricultural training, however, had no significant effect on the wheat-sown area.

Table 4. Estimation results of the DID models.

Variable	DID1 (1)	DID2 (2)	DID3 (3)
Dependent variable: lnWA			
$D_i \times T_t$	−0.16 * (0.08)	−0.26 ** (0.08)	−0.25 ** (0.08)
D_i	0.22 (0.12)	0.29 ** (0.09)	0.28 ** (0.08)
T_t	0.15 * (0.07)	0.15 * (0.06)	0.16 * (0.06)
lnWA		−0.31 *** (0.05)	−0.30 *** (0.05)
$TRAC$		0.24 *** (0.06)	0.22 ** (0.06)
AGE			0.03 * (0.01)
AGE^2			−0.00 ** (0.00)
EDU			−0.06 * (0.02)
EDU^2			0.00 ** (0.00)
AGT			0.08 (0.06)
Constant term	1.42 *** (0.09)	1.73 *** (0.12)	1.13 *** (0.29)
N	2063	2063	2063

Notes: Cluster robust (town level) standard errors in parentheses; *** $p < 0.01$, ** $p < 0.05$, * $p < 0.10$.

3.3. Parallel Trends Test

The time trend graph of the averages of the logarithmic values for the wheat-sown area is shown in Figure 4. In the 2013–2014 period, the trends for the treatment group and control group were essentially consistent in terms of the average logarithmic values for the wheat-sown area, exhibiting an upward trend. However, in the 2014–2015 period, the two groups showed different trends. The wheat-sown area for the treatment group showed a downward trend, which was consistent with the model estimation results, while the wheat-sown area for the control group showed an upward trend. The above analysis indicates that the model passed the parallel trend test.

3.4. Robustness Test

We first tested the robustness of the model estimation results by varying the control variables; the results are shown in Table 4. In columns 1 (DID1), we focus on the naive difference-in-differences estimators following Equation (1). Then, as shown in columns 2 (DID2), we added input variables (i.e., labor and tractor) to the naive model. Finally, we added all of the control variables. The results show that the coefficients of $D_i \times T_t$ are significant and the values are similar in all of the three models, indicating that the estimated results of this study have strong robustness.

Second, although the DID approach can eliminate geographical factors that do not change over time, our study area is too wide to control the time-variant geographical factors such as precipitation and drought. Thus, we narrowed the samples to three neighboring counties, Gaotang, Fan, and Qiu (Figure 3). The DID estimation results (columns 1 (DID4) in Table A2) suggest that the ATET of the impact of the grain subsidy reform on the wheat-sown area in the three neighboring counties is −28%, whose absolute value is three percentage points larger than the absolute value of the ATET in columns 3 (DID3) in Table 4. The results also support the robustness of our study.

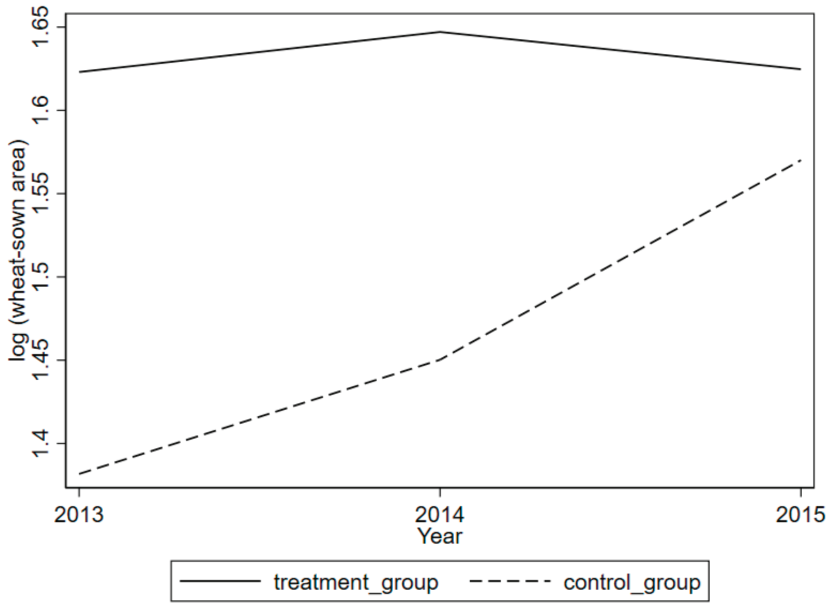

Figure 4. Result of parallel trends test.

Third, we compared our DID estimation results with the OLS model and fixed effects (FE) model using a dummy variable for the year 2015 (T_t in the DID model) as the proxy of reform. The dependent variable and control variables are the same as the DID model. The results listed in columns 2 (OLS) and columns 3 (FE) in Table A2 show that the coefficients of T_t are not significant. Considering the influence of unobserved factors that may lead to the endogeneity problem, the results of the OLS model and FE model are biased and unreliable.

3.5. Heterogeneity Effect

To further examine the heterogeneous effect of the subsidy reform on the wheat-sown area of farmers, we divided the wheat-sown area into three categories based on wheat-sown area 33%, 66%, and 100% percentiles. The threshold was 0.27 ha and 0.40 ha, respectively. Thus, the three categories were (1) Cat1: $0 < WA < 0.27$; (2) Cat2: $0.27 \leq WA < 0.40$; and (3) Cat3: $0.40 \leq WA \leq 2$ (the unit of WA is ha). The DID estimation results for the three wheat-sown area categories are shown in Table 5.

The results suggest that the subsidy reform had a significantly negative effect on farmers in Cat1 and Cat2, but no significant impact on those in Cat3. Specifically, the ATET of subsidy reform on farms in Cat1 and Cat2 was −9% and −4%, respectively. The results indicate that the effect of China's grain subsidy reform decreases as the wheat-sown area increases.

Table 5. Estimation results of the DID models for different wheat-sown area categories.

Variable	Cat 1 (1)	Cat 2 (2)	Cat 3 (3)
Dependent variable: lnWA			
$D_i \times T_t$	−0.09 *	−0.04 *	−0.11
	(0.04)	(0.02)	(0.06)
D_i	−0.01	0.00	0.05
	(0.07)	(0.04)	(0.06)

Table 5. *Cont.*

Variable	Cat 1 (1)	Cat 2 (2)	Cat 3 (3)
T_t	0.05 * (0.02)	0.02 (0.01)	0.10 * (0.04)
lnWA	−0.11 ** (0.04)	−0.03 * (0.01)	0.10 (0.04)
$TRAC$	0.15 *** (0.03)	0.02 (0.02)	−0.08 (0.04)
AGE	−0.00 (0.01)	0.01 * (0.00)	0.05 (0.05)
AGE^2	−0.00 (0.00)	−0.00 (0.00)	−0.00 * (0.00)
EDU	−0.03 (0.02)	−0.00 (0.01)	−0.04 * (0.02)
EDU^2	−0.00 (0.00)	0.00 (0.00)	0.00 * (0.00)
AGT	−0.01 (0.05)	0.00 (0.02)	0.06 ** (0.02)
Constant term	1.45 *** (0.33)	1.37 *** (0.10)	1.65 *** (0.39)
N	765	645	653

Notes: Cluster robust (town level) standard errors in parentheses; *** $p < 0.01$, ** $p < 0.05$, * $p < 0.10$.

4. Discussion

Increasing farm size was one of the aims of China’s grain subsidy reform in 2015. Results show that smallholder farms significantly changed land use by decreasing wheat production in Huang-Huai-Hai Plain instead of increase their farm size to receive more subsidies. We also found that the reform has the greatest impact on the smallest farmers. These results indicate that there is a positive relationship between subsidy amount and grain-sown areas. Our findings are consistent with those of Yi et al. (2015) [23], Zou et al. (2020) [37], and Guo (2021) [38], but different from those of Gale et al. (2005) [22] and Huang et al. (2011) [31].

The empirical results have important policy implications for promoting grain subsidy policy reform and ensuring China’s food security. First, China’s grain subsidy reform has reduced the wheat-sown area of smallholder farms. Although this reform was purported to increase farm size, it is still necessary to take into account the basic national condition that China is a “large country with smallholder farms” and the reality that smallholder farms are the primary business entity in farming. Therefore, while encouraging large-scale farms, it is necessary to take into account farmers’ small-scale operations and gradually promote the transformation of small-scale operations to large-scale operations.

From the perspective of international comparability, previous studies have shown that the reduction in subsidy or similar reforms would lead to a decline in land use. For instance, Ciaian (2007) and Helming and Tabeau (2018) found that the reduction in the Pillar I budget of the Common Agricultural Policy (CAP) of the European Union (EU) led to a decrease in utilised agricultural area [56,57]; Tranter et al. (2007) and Tzanopoulos et al. (2012) found that the 2003 CAP reforms, which decoupled of support payments from production decisions, led to a decline in the cereal and oilseed production area [58,59]. Tranter et al. (2007) also pointed out that farmers would like to transfer to produce forestry, woodland, and non-food crops [59]. In the United States, cropland acreage would also decrease if the payments of Farm Commodity Programs payments had been reduced [60]. Since China continues its reform in grain subsidy [18,61], those studies can also provide strong evidence about the potential impacts of subsidy reform to China’s policymakers.

To further investigate whether smallholder farms transferred their land out, we estimated a naive DID model based on Equation (1). The dependent variable is the amount of outflow land area. The results show that China’s grain subsidy reform has a significant and positive effect on the amount of outflow land area (Table A3). Thus, the impact pathway of China's grain subsidy reform is that smallholders might transfer their lands to large-scale farmers or cooperatives so as to decrease or terminate their grain production.

Previous studies found that if the smallholder farms transfer their lands to large farms, the land tenure increased accordingly [39,62]. We used another naive DID model to reveal the relationship between subsidy reform and land tenure (Table A3). The results show that the impact of subsidy reform on land tenure is insignificant, which is consistent with Lin and Huang (2021)'s study [63]. However, considering the evidence found by Tranter et al. (2007) [59] and the low ratio of profits to cost and expense in wheat production (1.77, −8.11, 0.61, and −15.74 in 2015–2018, respectively [64]), large farms may change the land use from producing wheat to cash crops or vegetables. Thus, the Chinese government should strengthen the supervision of land use to achieve the goal of ensuring food security. Furthermore, policymakers are suggested to improve the land rental market environment to protect the interests of smallholder farms.

There are several limitations to our study. First, since only a few samples in the SAVE data that we used are large farms, we only examined the effect of the subsidy reform on the land use behavior of smallholder farms. Therefore, the application of the results of this study is limited, and the impact of the policy reform on land use of large-scale farms is still unknown. Furthermore, whether large-scale farms continue producing grain is essential to China's food security. Second, limited by the unbalanced panel data, we could not investigate if the number of smallholders was decreasing or not after the reform. Third, as some farms do not transfer their lands, we could not further investigate how the land is used after farms reduced wheat planting. Additionally, although we found that the increase in grain subsidy payments for contracted farmland did not increase the farmland rental price, we still need more evidence to investigate who became the beneficiaries of the subsidy reform. Therefore, future research is required to answer the following questions empirically. (1) What are the impacts of China's grain subsidy reform on large-scale farms? (2) Will smallholder farms produce more cash crops or vegetables after the subsidy reform? (3) Who benefit more from the subsidy reform, smallholder farms or large farms?

5. Conclusions

In summary, we used the 2013–2015 Survey for Agriculture and Village Economy (SAVE) data and a difference-in-difference (DID) approach to empirically investigate the impact of China's grain subsidy reform on the land use of smallholder farms. Our study reveals three main conclusions. First, there is a negative impact of grain subsidy reform on the wheat-sown area. Influenced by the grain subsidy reform, a smallholder farm in Huang-Huai-Hai Plain would reduce 25% of its wheat-sown area. Second, the impact of subsidy reform is heterogeneous in scale. The smaller the farm, the greater the effect. Third, the impact pathway of China's grain subsidy reform is that smallholder farms might transfer their lands to large-scale farmers or cooperatives and thus decrease or terminate their grain production. At the end of 2013, the primary goal of China's agriculture policy was set to ensure basic self-sufficiency of grains and absolute security of food grains [65,66]. China's grain subsidy would like to be more precise and more focused on food security goals. Considering the fact that nearly 98% of farms in China are smaller than 2 ha [3,6], China can strengthen its food security only if farm size is successfully increased. Thus, how to increase farm size through subsidy programs would be an essential issue in future researches.

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Data Availability Statement: The data presented in this study are available upon request from the corresponding author.

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

Appendix A

Table A1. The number of sample farms.

Year	Hebei	Shandong	Henan
2013	152	168	395
2014	171	140	387
2015	190	101	359

Table A2. Estimation results of the DID, OLS, and FE models.

Variable	DID4 (1)	OLS (2)	FE (3)
Dependent variable: lnWA			
$D_i \times T_t$	−0.28 ** (0.10)		
D_i	0.10 (0.14)		
T_t	0.18 ** (0.07)	−0.04 (0.05)	−0.03 (0.03)
lnLB	−0.18 ** (0.07)	−0.29 *** (0.05)	−0.14 * (0.05)
$TRAC$	0.34 ** (0.12)	0.20 * (0.07)	−0.02 (0.02) (0.06)
AGE	0.06 ** (0.02)	0.04 ** (0.01)	0.01 (0.01)
AGE^2	−0.00 ** (0.00)	−0.00 ** (0.00)	−0.00 (0.00)
EDU	−0.08 ** (0.03)	−0.07 * (0.03)	−0.03 (0.02)
EDU^2	0.01 ** (0.00)	0.01 ** (0.00)	0.00 * (0.00)
AGT	0.03 (0.07)	0.08 (0.06)	0.03 (0.04)
Constant term	0.43 (0.54)	1.29 *** (0.33)	1.77 *** (0.38)
N	833	2063	2063

Notes: Cluster robust (town level) standard errors in parentheses; *** $p < 0.01$, ** $p < 0.05$, * $p < 0.10$.

Table A3. Estimation results of the impacts of subsidy reform on the amount of outflow land area and land tenure.

	The Amount of Outflow Land Area	Land Tenure
$D_i \times T_t$	0.17 *** (0.04)	0.10 (0.09)
D_i	−0.15 *** (0.02)	0.10 (0.09)
T_t	−0.11 (0.00) (0.10)	38.89 *** (0.70)
Constant term	0.26 *** (0.10)	118.17 (0.70) ***
N	2063	2063

Notes: Cluster robust (town level) standard errors in parentheses; *** $p < 0.01$.

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Article

Location of Coworking Spaces (CWSs) Regarding Vicinity, Land Use and Points of Interest (POIs)

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Abstract: Background: The place of work is, besides the place of residence, a main travel destination in the course of the day for working people, who make up the majority of western European societies. Other daily destinations, such as those for childcare, social activities, and buying groceries, are spatially related to both of these. This article aims to detect if and how the character of the neighbourhood and the associated land use is related to the location of coworking spaces. Specifically, we investigate the spatial relation between coworking spaces (CWSs) in peripheral and non-peripheral regions to specific points of interest (POIs). These POIs could be daily destinations relevant for a common lifestyle of working people. The data rely on identifying the location of CWSs (peripheral/non-peripheral, land use) in Germany and relating the location of CWSs to the location of POIs using georeferenced data. The results show an accumulation of CWSs and POIs in non-peripheral regions and residential areas and a higher number of specific POIs in their vicinity. From these results, we infer that a relatively higher number of specific POIs in the vicinity of CWSs makes it more likely to use this service and thus provides specific advantages to users of CWSs. If work is performed in a CWS close to the place of residence, other daily destinations could be reached in a short time and the spending capacity could remain in the local economy. The quality of life could increase, and the commute is shrinking with effects on traffic, carbon emission, and work–life balance. Further research could investigate whether this also occurs in an international context, and could focus on developing social-spatial models, by making of use remote sensing. In this way, one could measure the impact on public space and on the neighbourhood of CWSs more quantitatively.

Keywords: rural development; depopulation; diversification; sustainable development goals; coworking; points of interest; urban planning; 15-Minute City

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1. Introduction

Villages and town centres, especially those located in rural, non-metropolitan regions, and, to a lesser extent, outskirts of metropolitan regions, face several problems. The number of inhabitants is shrinking [1,2], causing vacancy of houses and shops [3] and leaving land either un- or underused [4,5]. For those who remain, work opportunities tend to be in towns [6], leading to both monofunctional and structurally weak villages ('villages without people') as well as monofunctional villages in peripheral areas ('sleeping villages') [7,8]. As professional life and private life is therefore disconnected spatially, people have to travel to work, re-enforcing the village decline and increasing commuting behaviour [9]. Despite these trends, many of these commuting village residents still prefer to enjoy the comfort of a private garden [10,11] and are still dreaming of an individual, detached house [11]. The concept of a 'Garden City' by Ebenezer Howard [12,13] (late 19th century) aimed to avoid slums and protect the population from unhealthy environmental conditions (such as polluted air and water, which was often caused by industrial sites in the vicinity of residences). In combination with the ideas of the 'Lebensreform' [14] from the mid-19th century, which aims to bring human life back to nature, this led to a trend of separating the place of work (factories, plants, etc.) from the place of residence. The spatial separation of the workplace and residence place derived several concepts of a modern city, such as Ebenezer Howard's 'Garden City', Tony Garnier's 'Cité Industrielle', Frank Lloyd Wright's 'Broadacre City', and Le Corbusier's 'Ville Radieuse' [15]. However, such 'modern' towns additionally lead to large volumes of daily commuting, traffic jams, additional road constructions, empty and sleeping villages, and gradually to more CO_2 emissions [16]. In the last decades, the amount of work performed in factories by blue-collar workers or in agriculture has been shrinking in Western societies [17], and the reason for the separation of the place of work and the place of residence, to protect people from harmful emissions, is no longer necessary to this extent. This can bring jobs, especially in the tertiary sector, closer to the place of residence.

Given the above, the objective of this article is to identify concepts of white-collar office work, which could bring the place of work into the vicinity of the place of residence.

Despite the significance of these concepts at the time and during the 19th and 20th century, for the 21st century, many of these ideas, and subsequent city and village designs have, however, led to multiple problems for villages, such as the vacancy of land and properties, sleeping and mono-functional villages, traffic, land-taking, and environmental problems. One of the contemporary alternatives to combat these problems could be sustainable coworking spaces, located in rural villages and mixed-use areas, with a versatile range. The justification for this option is that it would bring more vitality to the villages and thus enable more economic and social development. The degree to which this assumed effect is valid is, however, so far unknown. Therefore, this article aims at deriving which factors (location, amenities/services in the vicinity, etc.) could contribute to successful or unsuccessful coworking places in the sense of vitality, versatility, and sustainability.

Considering the strong relationship between the place of residence and the place of work on the one hand, and the frequent combination of the commute with other destinations on the other hand, it seems to be relevant where coworking spaces are located and which other potential destinations are located. Assuming that coworking spaces are increasingly spreading not only in large cities but also in rural areas, it seems important that they are not established somewhere, e.g., in an industrial area, but rather where they are easily accessible and can be combined with other destinations on multipurpose trips. Based on these relations, we have formulated the following research questions:

1. Where are coworking spaces (CWSs) located, in peripheral or non-peripheral regions?
2. What kind of land use is characterizing the surrounding of coworking spaces?
3. Which amenities, services and offers (specific POIs) are located surrounding CWSs, and where, that can be relevant for users and tenants?

Amenities, services and offers (specific POIs) in the vicinity of CWSs could attract users and tenants to CWSs, and at the same time, the neighbourhood also could become more attractive due to a higher frequency of people, to which the CWS can also contribute.

This article contains the subsequent sections, in line with the research questions. It first describes the (German) legal, social and historical context in which the separation of work and residence developed. The following section (Material and Methods) explains the data collection and data analysis methods to address the main research questions. The next section summarizes the main findings and results, followed by a discussion section which relates the findings of the research to the existing literature. The limitations of the research are validity in the next section, and recommendations for further research are drawn. The final concluding section provides the main answers to the research questions and provides recommendations for the practice.

This article provides an analysis of the spatial relation between coworking spaces (CWSs), land use and POIs, which are relevant for working people for daily use. The relevance of spatial proximity and the densities of amenities in different land-uses can be seen here. We consider our findings relevant for a spatial planning approach that aims to avoid CO_2 emissions and other disadvantages of motorized individual transport (MIT) and to make rural areas and inner-town locations more attractive through offers, services and, e.g., coworking spaces, which are relevant in the daily routine of working people.

Germany was chosen as the region of interest, as data on CWS locations and POIs were available in a sufficient quantity and quality.

2. Literature Review of Legal, Social and Historical Context of Separation between Work and Residence

This spatial relation leads, among other things, to dormitory towns [7,18] and an increasing volume of traffic [19]. A spatial redistribution of knowledge work in the tertiary sector, made possible by digitalization [20], could enable a stronger provision of labour in rural areas and villages [21].

2.1. Separation between Work and Residence

The spatial relationship between the place of work or education and the place of residence is the most important spatial relationship in people's lives besides the issues of daily needs and social life or leisure activities [22]. There are several explanations for why there is currently a separation between work and residence. Historically, the separation of the workplace from the residence place arose during the era of industrialization [23]. Before industrialization, the place of work was close to or within the place of residence [24–26]. Industrialization's demand for labour attracted people looking for employment, who settled close to the workplace for easy access to life where the work was.

2.2. Dwelling and Cities of the Modern

Following the conceptual idea of the functionally separated city [12,27], new housing estates, factories and production plants were built on separate locations, with the aim to protect people from harmful emissions. This concept, however, caused a number of problems for residents and working people [23]. To deal with these problems, several planners with philanthropic aims [28] developed a city design with a functional separation to protect people from environmental harm [15,27]. In Germany, this conceptual separation is legally manifested in the German Building Use Ordinance—"Baunutzungsverordnung (BauNVO)". Legally, the place of living is defined as the place of first or second residence (Federal Registration Act—"Bundesmeldegesetz (BMG)" § 20 habitat, habitual residence or domicile [29]. This is the apartment or house—a home where people sleep regularly and run a household. Contrastingly, the place of work (or the place of employment) is the formally registered location of the employer or a branch of the employer. According to the Trade, Commerce and Industry Regulation Act—"Gewerbeordnung (GewO)" § 106, an employer has the right to determine where an employee is to perform the work [30].

2.3. Functionally Separate Areas

In the context of Germany, this idea translated into so-called 'core areas' following the German Building Use Ordinance § 7 core areas (in German: 'Kerngebiete'). Core areas primarily serve to accommodate commercial enterprises but can also define the designation of central economic, administrative and cultural facilities [31]. With the Building Use Ordinance of 1962, dwellings and residential facilities were largely excluded in core areas [32]. As a direct consequence, the number of inhabitants in central parts of cities and towns [33,34] shrunk. Another direct result was the preference for non-residential facilities, as the economic gains were significantly higher for commercial facilities such as offices and retail [35,36].

2.4. Commuting Is a Consequence of the Separation of Home and Work

Currently, however, being mobile and travelling between the place of residence and the place of work, by public transport and cars, makes the separation of the place of work and the place of living increasingly possible, yet it also leads to an increase in daily commuters [22,37]. In general, one could state that the importance of the physical distance being a barrier is declining. This process is described as "distance decay" [38]. It enables people to enjoy more greenery and gardens and to build new detached houses at the outskirts of towns and villages.

Socially, the separation of the place of work and the place of living causes the commute, which is sometimes just a short bicycle ride, but often a commute by train or car, to take up to more than one hour, and this is steadily increasing [9]. The number of commuters is also rising [39]. Commuting is reported to lead to unhappiness and stress, especially if the commute is not by active modes of transportation (cycling, walking) [40,41]. People perceive it as a waste of time, and many are feeling guilty for the ecological damage of CO_2 emissions caused by commuting [16,42,43]. Performing the commute by car still emits CO_2/greenhouse gas [44], demanding parking and road space [45]. This counteracts sustainable transport (as recommended by the United Nations Secretary-General's High-Level Advisory Group [46], Sustainability Strategy of Germany [47], and the National Platform Future of Mobility [48]).

If the work location is close to the residential location, and/or when the commute can be performed on foot or by bicycle, commuters tend to spend money in the vicinity for personal commercial activities, and thus contribute to the small and medium economy within the vicinity of the work place [49]. Commuters can be considered as relevant for the local economy [50–52].

2.5. Sprawl and the Donut-Effect as a Consequence of Commuting

The result of a rising amount of commuters is an emerging suburb, suburbia [53] or exurb [54], manifested in urban sprawl. The sprawl not only grows in the immediate vicinity and surrounding of cities and metropolises, by there are also edge cities [55] reaching out in the country and there are likewise rural sprawl enabled mainly by car traffic [56]; inner-villages are decaying [57], and this causes the donut effect [58–61], wherein villages grow with new detached houses with shopping and commercial districts at the outskirts, whilst houses and shops in the previous village centre become abandoned. The central village and town areas decay while the outskirts expand and the built-up town structure forms a donut—the so-called donut-effect [60,61].

2.6. Knowledge Work and Digitalization

With digitalization and the rising share of non-physical, knowledge-based work [62] from the so-called 'creative class' (following the terminology of Richard Florida [63]), the place of work is decoupled from the location of the employer, which enables more remote work and telecommuting [64–66]. Besides the employed white-collar worker, there is a rising number of freelancers, which perform knowledge-based work and are already not bound to the location of their clients [67].

The current society also needs highly specialized knowledge workers [68], yet many of them cannot find an appropriate job at their desired location [69]. Traditionally, they would have to relocate to the place of the employer. However, with the opportunities of modern remote work for telecommuting, they could in theory be free to choose the place of residence according to their personal preferences and thus be able to travel to the location of the employer for specific purposes only, such as for in-person meetings [70]. This behaviour was visible during the forced COVID-19 lockdown [71,72], although it also led to social isolation [73] and people being stressed about coalescence of private and professional life or the double task of remote work and home schooling [74].

2.7. Coworking Spaces

Performing work in a coworking space could be an alternative option, by separating the place where work is performed from the place where private and family-related tasks occur. A coworking space is a location, similar or comparable to an office, mainly as an open space office, often with a higher quality of design and a more differentiated offer of workplaces, desks, meeting rooms, phone booths, lounges, etc. [75,76], where people are "working alone together" [77] in a social context, with "colleagues" that do not have to have the same employer. As Merkel described it, "Coworking is hence not just about working 'alone together' or 'alongside each other' in a flexible and mostly affordable office space. It is also underpinned by a normative cultural model that promotes five values: community, collaboration, openness, diversity, and sustainability. This 'collaborative approach' is always underlined as a distinctive feature that sets coworking apart from other forms of shared, flexible work setting such as satellite offices, hot desks, coffee shops or business incubators" [78]. However, the boundaries seem to be fluid, and the term "coworking space" is often used by business centres or shared offices alike—or as a specific subtype of business centres [79].

Coworking spaces in rural regions could represent locations to conduct work [21,80]. The attractiveness of coworking spaces not only reflects the attractiveness of the coworking space itself but also reflects the attractiveness of its vicinity [81]. Hence, there is a correlation between job opportunities, depopulation and services offered in a spatial context. The opportunities have already been recognized, and there are some initiatives, such as CoworkLand eG, and programmes that support this. The German funding database [82] identifies around 499 funding programmes under the search terms 'land' and 'digital', one of which explicitly includes the term 'coworking space' [83]. The Federal Ministry of Food and Agriculture supports the idea of rural coworking spaces [84].

Coworking spaces could also be supported by programmes such as LEADER, ZILE 'Integrated rural development in Lower Saxony' [85]. The new coalition agreement of the Federal Government [86] states that "Coworking spaces are a good opportunity for mobile work and strengthening of rural regions". Despite the fact that this policy has not yet seen any concrete activities, at least the intentions for the coming years are clear. At the European level, there are—besides the existent rural development programs (RDPs), such as LEADER etc.—new initiatives such as the 'Long-term vision for the EU's rural areas', the 'Rural Pact', the 'EU Rural Action Plan' [87]; rural coworking spaces are matching with the Priority & Focus Areas 1 and 6 [88]. Several sections of the EU's 'Green Deal' of 'The New European Bauhaus' [89] could support the idea of coworking spaces, especially in rural regions. Last but not least, the European Network for Rural Development (ENRD) provides a 'Rural Coworking Guide' dealing with the general issues in rural regions, business/management models, needs, equipment, networking and communication [90].

There are several websites [91–94] that provide tools to find a coworking space using searching filters with different criteria, including the available equipment, rental price, availability and location. When evaluating the possible locations, it is obvious that most coworking spaces are in urban regions. However, increasingly, there are also coworking spaces in rural areas [80,95–97]. Previous publications also confirm this [97–99], arguing that with the presence of co-workers in rural areas could reactivate the use of previously abandoned houses in rural village centres. Regardless of whether of the location is in rural or non-rural areas, it is still largely unknown to what extent the location of a CWS relates to land use or to the presence of other specific facilities and services. Mariotti et al. posit that the location of a CWS strongly depends on a particular set of spatial artefacts. Their analysis locates CWSs, regarding the NUTS4 (Nomenclature des Unités territoriales statistiques—since 2005, local administrative units (LAUs) [100]), and found a dominance in urban areas, followed by suburban areas and " ... to a lesser extent, peripheral and inner areas" [101]. In addition, specific types of land use may influence the occurrence of CWSs, which has been studied through some research [102–104]. Still, however, these examples are rather isolated and do not reflect a regional or national pattern.

Conducting work in a coworking space is a reflection of the separation of professional from private life [72,105], and an alternative to execute the job from a "Third Place" (other than home or office [76,106,107]. As such, working from a coworking space close to the place of residence could facilitate a better work–life balance whilst avoiding the need to physically commute, thereby creating the possibility to socially isolate [98,99].

CWSs not only offer advantages for their users: the respective nearby areas also benefit from the presence of a CWS, as it brings vitality to the neighbourhood [81,108] and increases spending at local businesses, especially when the trip to and from the CWS is carried out on foot or by bicycle [109,110].

All the aforementioned aspects are geographically related. The distance between the place of residence and place of work (in a coworking space with the provided services) matters. To travel between these geographical destinations in the course of the day is a demanding task. If these daily destinations are located close to each other, the required time and effort is relatively low, which could imply that the distance is more likely to be covered by walking or riding a bicycle [111,112].

2.8. City Schemes Regarding Vicinity Are Back

The documented evidence about travel behaviour related to the place of work is, however, fragmented, especially when the workplace is in a coworking space. Additionally, there is still limited evidence about the extent of the spatial inter-connection between the presence of small and medium commercial enterprises in the vicinity of the coworking places. There exist, however, several geographical and planning models that theorize the relationship between work and residence in general. This includes the general planning ideas captured in the Charter of Athens, the neighbourhood idea of Jane Jacobs [53], the models related to points of interest, etc. While the Charter of Athens propagates the separation of functions of the built environment in residential districts, with districts for production and for commerce and leisure, Jane Jacobs follows a different concept wherein people from different backgrounds and origins could meet by reducing boundaries. Points of interest (POIs) provide the potential for people to meet because they are of a more or less common interest. Following this thought, the availability of a high number of POIs close to the place of residence and place of work increases the chance for people to meet other people.

Newly developed areas on the outskirts of towns and villages are separating commercial and residential uses for several reasons. First is the dominating idea of the separation of uses according to the "Garden City" [12], with the ambition to protect people from the harmful emissions of industrial sites. Secondly, the concept of separation became the guiding idea for urban planning in the 20th century and has been incorporated in the "Charter of Athens" (1933) [27], an influential work on planning. The German Federal Land Utilisation Ordinance (Baunutzungsverordnung—BauNVO) still follows the ideas of the Charter of Athens, by defining the specification of land use by allowing only certain listed land uses and prohibiting others that are not listed. This is the legally binding implementation of the goal formulated in the Charter to separate the areas of the city according to their functions [32].

In the time between the concept of separating land uses to protect people from harmful emissions (late 19th and early 20th century) and today, the economy has developed from an industrial to a knowledge-based economy of service and finance [17,113], which has reduced many of the harmful emissions and enabled a borderless use of land where, e.g., commercial and residential uses could directly meet each other and be intertwined with one another [114]. Some current planning schemes, such as the 15-Minute City, are taking this into account, but these concepts are rarely implemented and more traditional functionally separate structures are specified by the legal framework (BauNVO), adopted by municipalities as land use plans and then built. Hereby the land take is mostly above the population growth [115]—if it grows at all [116]. Municipalities, which have planning sovereignty in Germany (German Constitution—GG Art. 28), finance themselves to a considerable extent through revenue from trade tax (GG Art. 106), which is paid by resident companies. Therefore, municipalities tend to designate large areas for commercial use in order to facilitate the settlement of companies. Partly due to this oversupply, land prices here are often below those for other land uses [117].

The concept of the "15-Minute City" [118] considers locations of immediate daily needs for an individual relevant if they are located within a fifteen-minute time distance. Such points of daily needs and services can be considered POIs [119]. However, daily needs and services highly vary depending on the household and family situation, and it is this complex set of possibilities where various types of destination (grocery store, school, childcare, office (or coworking space) business trips, sport, leisure, recreation, etc.) need to be combined. This creates a city concept in which variety and complexity play a crucial role in constructing space, which is conceptually the opposite of other city construction concepts such as the "Charter from Athens" and a resurgence of the neighbourhood idea of Jane Jacobs [53]. The younger opposites to the concepts of the modern Charter of Athens—with a functional and spatial separation—advocate for the necessity of having close spatial relations, mixed uses and walkability to needs and services in order to foster sustainability, vitality and liveliness. The 15-Minute City may even contain neighbourhoods or communities in which everything is accessible within 5 min [120]. The concept of mixed use and accessibility by vicinity is to be found in the "New Leipzig Charter" as well [121]. For the particular household set of the family and elderly people, such a closer concept of a neighbourhood with walkable distances to all possible services (including health facilities) would be a preferable solution to city designs in which such services are centralised in specific large-scale, high-volume locations [122–124].

Ridwan and Dimas evaluate to what extent land use und local features in the city of Bandung have an effect its the attractiveness to creative people. It was found that proximity to, for example, coffee shops, bars and sport facilities is of significant importance for the attractiveness of higher educational facilities (such as universities or research centres) [125].

Services that are of relevance for daily needs include grocery stores, supermarkets, restaurants, cafés, public transport, bakeries, kindergartens and cinemas, amongst others. These are all places or points—in a spatial sense—and thus have a specific location, reflected as points of interest (POIs) [126]. The above-mentioned POIs (grocery stores, supermarket, etc.) can be combined with trips for different purposes [127,128].

In light of the above-mentioned aspects, we can consider the land use surrounding coworking spaces and the specific networks of services functional if they combine multiple purposes and if they are spatially related to coworking spaces.

3. Methods and Materials

There is a wide and rapidly growing range of literature on the subject of coworking spaces, fablabs, etc., as it could be found, e.g., at the Coworking Library [129]; however, we found a limited amount of literature on our research focus—the spatial relation of CWSs and POIs. The theoretical concepts, ideas and models insufficiently capture current realities of remote work and coworking. Additionally, they do not capture the reasoning and justification for certain choices of coworkers. For this reason, this research aims to collect more data on these issues and try to find alternative interpretations. We decided to investigate the research questions by analysing the location of CWSs on different spatial scales: firstly, the general location—peripheral or non-peripheral; secondly, the dominating land use, where CWSs are located; and thirdly, where services and offers, which could be relevant for users of CWSs, are located in the vicinity of CWSs. This investigation should be based on data on the location of CWSs, on land use and on the location of other relevant offers and services. The location of offers and services could be identified by using the available data of POIs, which are partly relevant offers and services.

The use of POIs is, however, useful in the context of this work, because POIs are spatial locations which are relevant, i.e., of interest, to people. POIs are providing a location of a service, an offer, of something else what people could make use of or interact with [130]. In addition to the benefits for users using POIs also provides the opportunity to investigate the degree to which the presence of several CWSs in a specific neighbourhood provides spatial benefits.

POIs are collected by different services, e.g., Google Maps, Foursquare, OSM, etc., with a different number of categories and focus areas. This data collection relied firstly on identifying the locations of existing coworking spaces. Information on the location, name and address of the respective websites of coworking spaces was collected from the website www.coworkingmap.de (accessed on: 8 April 2021), which is a current and comprehensive collection of coworking spaces, with geo-referencing, accessed in early 2021, as a basis of this research. From the source www.coworkingmap.de (accessed on: 8 April 2021) is a current, comprehensive and reliable source of coworking spaces and mainly focus on coworking spaces in Germany.

The next step of the data collection concerned the classification of coworking spaces. This classification followed both the spatial and non-spatial aspects. At first, coworking spaces were separated into two groups: peripheral and non-peripheral. The definition of peripheral and non-peripheral is based on the harmonised definition of functional urban areas (FUAs) developed by the Organization for Economic Cooperation and Development (OECD) in cooperation with the EU. This definition includes cities and their commuting zones [131]. The OECD defines cities as "a group of local administrative units (i.e., LAU for European countries, such as municipality, local authorities, etc.) where at least 50% of its population live in an urban centre. An urban centre is defined as a cluster of contiguous grid cells of one square kilometer with a density of at least 1,500 inhabitants per square kilometer and a population of at least 50,000 inhabitants overall." [131] According to the definition of Workgroup 1 of the COST Action 'The geography of New Working Spaces and Impact on the Periphery' (CA18214), we decided to classify FAUs below 200,000 inhabitants as peripheral and above 200,000 inhabitants as non-peripheral. In total, there were 96 such FAUs in the dataset of the OECD.

The location of a coworking space is thus classified as "peripheral" if: (a) 1, the coworking space is located outside a metropolitan region, or if they are located within the metropolitan region and this region has less than 200,000 inhabitants; (b) 0, the spaces are located within a metropolitan region with a population more than 200,000 inhabitants. To illustrate these criteria, we list some examples here:

- CWS location outside a metropolitan region—attribute = 1
- CWS location within a metropolitan region that has less than 200,000 inhabitants—attribute = 1
- CWS location within a metropolitan region that has more than 200,000 inhabitants—attribute = 0

To identify the character of the surrounding location of the coworking spaces, we chose the land use database of www.geofabrik.de (accessed on: 8 April 2021), which is based on the OSM database, with the following categories of land use (Table 1). The origin database from OSM is rated as very accurate [132]; these are provided by Geofabrik.de, which are used in other research projects on accuracy [133,134]. Geofabrik.de transferred the OSM database into shapefiles to make the data useable for GIS [135]. In a first step, we joined the location of the coworking spaces with the categories of land use in ArcGIS. For the 80 remaining unclassified coworking spaces, a corresponding OSM class was added by hand using aerial photographs and an existing open-source land use dataset (OSMlanduse.org). This leaves 10 spaces that cannot be clearly classified. Classification of the land use/landcover in the OSM dataset compared with the ATKIS (Authoritative Topographic–Cartographic Information System) shows a high level of completeness and correctness, especially in more urbanized areas [136].

Table 1. List of the types of land use from the database www.osmlanduse.org (accessed on: 8 April 2021).

Categories of Land Use
residential
commercial
industrial
retail
grass
farmyard
meadow
forest

Different sources generated the georeferenced information of POIs. One of easiest and most user-friendly ways is to rely on the technical facilities of Google Maps. Additionally, data were collected from German spatial data agencies, such as the BKG—Bundesanstalt für Kartographie und Geodäsie (Federal Agency for Cartography and Geodesy), which provides a specific range of POIs. Furthermore, we relied on open-source services such as *OSM,* which provides a huge amount of georeferenced data by free access. More than 8 million users provide 8.9 billion GPS points, complemented with tags (attributes) [137]. There are no pre-defined categories for POIs in the OSM database, so there could be countless variations of the same kind of POI, with different names, but there is a critical community that takes care of ensuring accurate data, which is entered into the database by registered users. Each entry in the OSM database is stored with the database of the entry. This provides a highly transparent dataset and with that a source of quality assessments [138]. In particular, the accuracy of the shop location, which is an important interaction node for the users of coworking spaces and generates vividness in public spaces, is assessed as "high estimated completeness level of retail stores" [139,140].

Based on the above-mentioned publications and insights, we decided to use the database of OSM processed by Geofabrik.de as the source for the location of POIs. We used the OSM dataset of POIs from Geofabrik.de because they show a lower lack of ambiguity in the classification of POIs. From the OSM database, we selected the POIs with tags, as listed in Table 2 below.

From the OSM database, 2,668,989 POIs of the classes 'pois_free' (not further defined) and 'transport' from all 16 federal states of Germany were loaded in the GIS system. After filtering out the attributes listed in Table 2 ('pois_free' and 'transport'), 742,067 POIs remained. Of these 742,067 POIs, 41,155 duplicates were filtered out. The 500 m radius was chosen regarding the accessibility, walkable distances [122] and the concept of neighbourhood [120]. The spatial join of the 500 m radius around the CWSs reduced the number of POIs to 41,166 POIs as a total set in the radius of 500 m around the coworking spaces. In a normal working day, the primary journeys are to and from the place of work, supplemented by journeys to shops, eateries, pharmacies, local transport facilities, childcare facilities, sports and cultural facilities or similar places [141,142].

These are exported as a shape file. A *1:n* left inner join (spatial join via the geometric relationship "intersect") results in an assignment of the POIs to the respective coworking spaces based on a spatial join used with 500 m circular zones around the coworking spaces. This results in a table with 56,422 entries. The absolute number of POIs is lower because some POIs are located in the vicinity of several CWSs. Twelve coworking spaces do not have a POI in their vicinity and were therefore excluded from the calculation. This results in a total of 6096 entries in peripheral areas and a total of 50,326 entries in non-peripheral areas.

As described above, we identified more than 41,000 POIs in the vicinity of coworking spaces (radius 500 m), excluding POIs located within a 500 m radius of several CWSs. The listed POIs (Table 2) were joined with the land use categories (Table 1) in a spatial intersection process of the GIS Software.

We have selected the POIs in Table 2 with regard to their usefulness in the everyday life of the working population, 26 out of 135 in the category 'Points of Interest' and 5 out of 10 in the category 'Points of Transport'.

Table 2. List of the chosen tags from the processed points of the OSM databased in the categories "Points of Transport" and "Points of Interest".

From the 10 Tags in the Category "Points of Transport"	From the 135 Tags in the Category "Points of Interest"
bus_station bus_stop railway_halt railway_station tram_stop	bakery bank bar beverages bicycle_rental bicycle_shop biergarten bookshop butcher café car_sharing cinema community_center convenience doctors fast_food greengrocer kindergarten kiosk laundry library pub restaurant school supermarket theatre

The chosen POI seems to be relevant for a regular interaction with repetitive work at a coworking space.

4. Results

4.1. Analysis of Peripheral and Non-Peripheral Locations

We first intersected the location of coworking spaces with the shape files of the FAUs provided by the OECD using ArcGIS. We found 149 coworking spaces in peripheral locations, outside of FUAs, according to the definition of the OECD and 562 coworking spaces in non-peripheral locations within FUAs. A majority of 79% of the analysed coworking spaces are located in FUAs or in peripheral regions and 21% outside of FUAs or in peripheral regions within FUAs. Cities and their interconnected region are still the major home for coworking spaces (Figure 1).

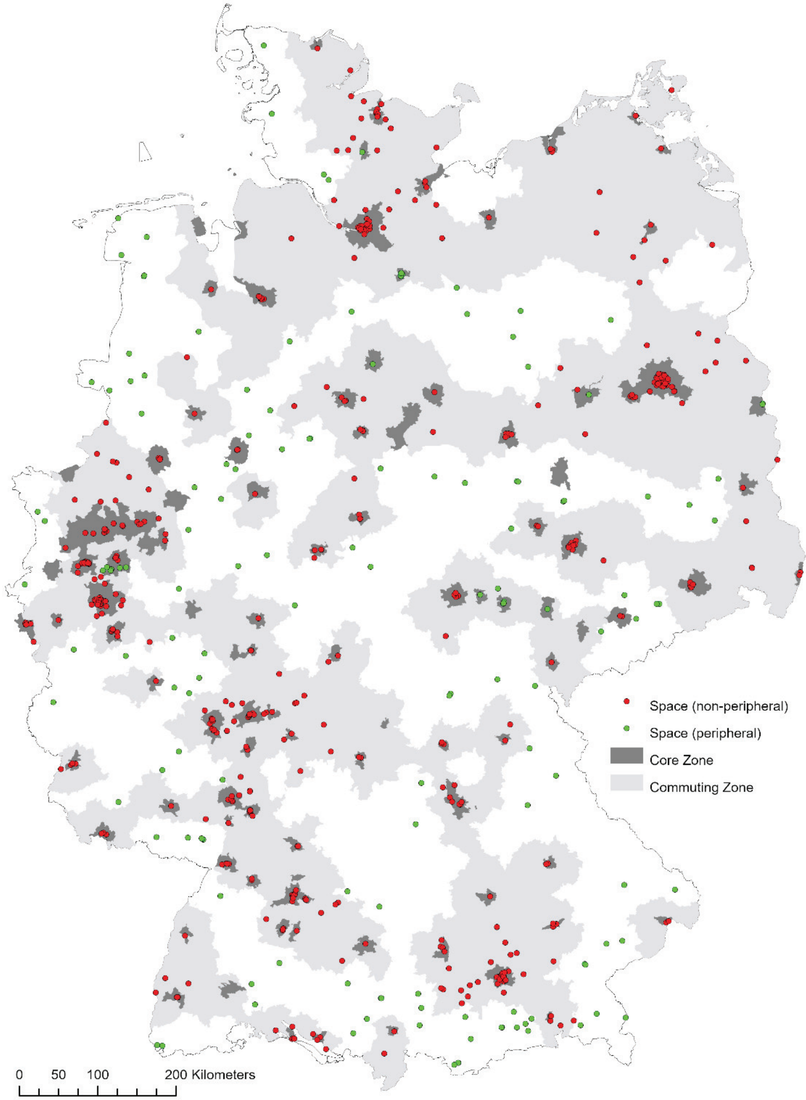

Figure 1. Location of coworking spaces (green dots: in peripheral areas, red dots: in non-peripheral areas, dark grey: core zones, light grey: commuting zones) in Germany interlaced with the FAUs defined by the OECD, source: own illustration based on © GeoBasis-DE/BKG (2020), www.coworkingmap.de (accessed on: 4 June 2021).

Reasons for the dominance of non-peripheral location of coworking spaces are probably the higher population density and the fact that such facilities are used by a rather young, urban clientele.

By comparing the location of coworking spaces with the categories of land use (OSM data) via the GIS system, we could classify 701 coworking spaces. Some that did not join the shape files of the land-use categories were classified by analysing areal images from ArcGIS Pro, Google Maps, Google Earth, and www.geofabrik.de (accessed on: 8 April 2021).

4.2. Analysing the Location of CWS by Land Use

We found that a majority of coworking spaces is located in residential areas, 63% (450 of 711), 20% in commercial areas, 8% in industrial areas, 7% in retail areas and in sum 2% in more agricultural surroundings such as grass, farmyards, meadows and forests.

Reasons for the dominance of coworking spaces in primer residential neighbourhoods are probably the higher population density and the easier accessibility due to a shorter distance from the place of residence.

Regardless of whether a site is located in a rural or urban area, the analysis shows that a majority of coworking spaces are located in residential areas.

To observe the difference between peripheral and non-peripheral areas in the type of surrounding land use, we separate the examination group into non-peripheral (Figure 2) and peripheral (Figure 3).

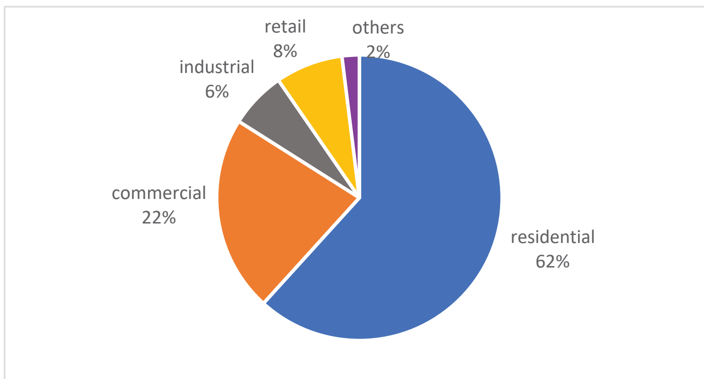

Figure 2. Distribution of coworking spaces related to the type of land use for non-peripheral areas.

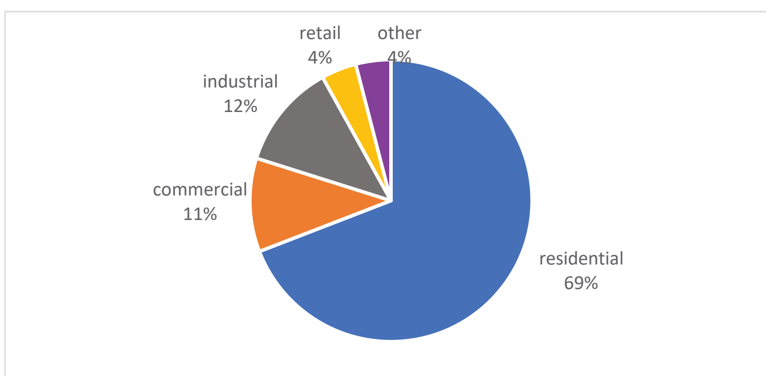

Figure 3. Distribution of coworking spaces related to the type of land use for peripheral areas.

The majority of land-use types where we could find coworking spaces is residential in non-peripheral areas, with 62% (Figure 2). A total of 22% of the coworking spaces are located in commercial surroundings, 8% in retail-dominated surroundings and 6% in industrial surroundings.

If we take a look at peripheral areas, the picture is changing. Here, we still have the highest share of coworking spaces in surroundings categorized as residential with 69%. A share of 11% of the coworking spaces are located in commercial surroundings; 4% in retail surroundings; 4% in others, such as meadows, farmyards, forest, etc.; and 12% in industrial areas (Figure 3).

Reasons for the dominance of coworking spaces in prime residential neighbourhoods are probably the higher population density and the easier accessibility due to a shorter distance from the place of residence. The lower share of coworking spaces in industrial neighbourhoods could be due to the fact that car use is dominant in rural and peripheral regions and there are more parking spaces available due to the lower density of buildings in industrial neighbourhoods. The halved value for commercial and retail locations of coworking spaces was the same between non-peripheral and peripheral regions. This could be due to the fact that explicit retail and commercial areas do not exist or can be identified less frequently here. The variation in the share of land use (absolute numbers) where CWSs are located is compared in Figure 4, between peripheral, non-peripheral, and in total.

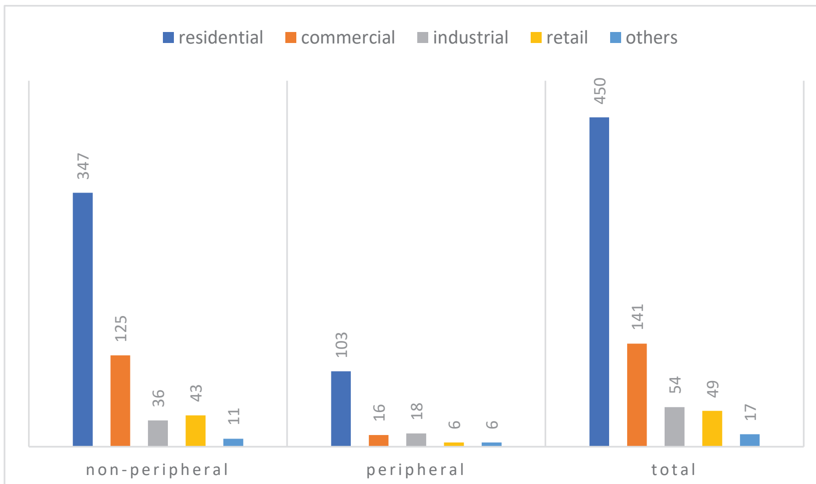

Figure 4. Comparison of the distribution of coworking spaces related to the type of land use for peripheral and non-peripheral areas, and in total.

4.3. Analysing the Spatial Relation of CWSs and POIs

The POIs listed in Table 2 are relevant for daily needs, regular uses and social or cultural issues. The spatial relation to the place of residence and the place of work is of significance. The POIs from Table 2 and the place of residence and place of work are the main destinations of everyday mobility [51,52]. In our study, the place of work is a coworking space.

A distance of 500–1000 m can be considered a walkable distance [124]. Therefore, we chose a lower limit of 500 m as a walkable distance to ensure the comfort of walking accessibility. By creating a 500 m radius around the individual coworking spaces, we selected the POIs inside this circle as easily accessible and analysed their amount per type.

In the vicinity of an average coworking space, we found more than 14 'restaurant' POIs, as shown in Figure 4, more than 8 'bus_stop', 7 'café', nearly 4 'bakery', and 2,1 'supermarket' POIs, as shown in Figure 5.

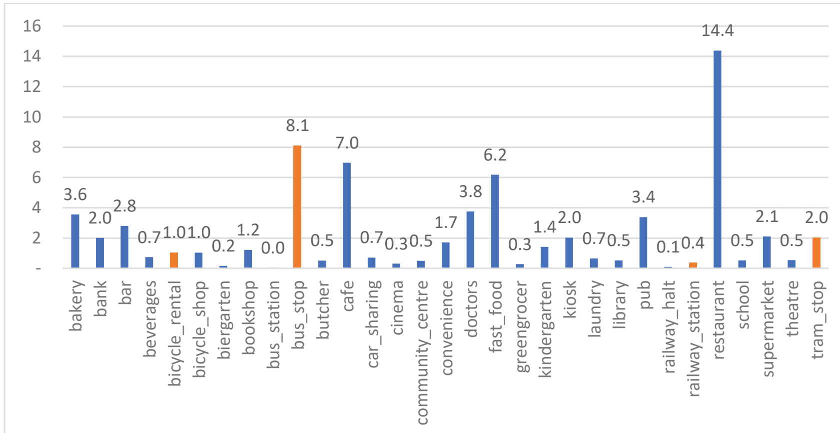

Figure 5. Average number of different POIs in the vicinity of 500 m in the surrounding of coworking spaces in peripheral and non-peripheral areas.

The reasons for these findings could be the relatively high number of POIs, such as 'restaurant', 'bus_stop', 'café', etc. in dense and more residential or commercial areas where coworking spaces are mainly located. In further steps, we compared the number of POIs around coworking spaces (radius 500 m) in different locations by their land-use category and regional character as peripheral or non-peripheral.

As visible in Figure 6, all POIs are most available in areas with a dominant land use of 'retail', especially 'restaurant' (27,7), 'fast_food', 'café' and 'bus_stop', with more than 10 POIs in the vicinity. Compared with locations dominated by 'residential' land use, the number of POIs 'restaurant' is below 20, in locations dominated by 'commercial' land use, the number of POIs 'restaurant' is below 10 and in locations dominated by 'industrial' land use the number of POIs 'restaurant' is at 1.6.

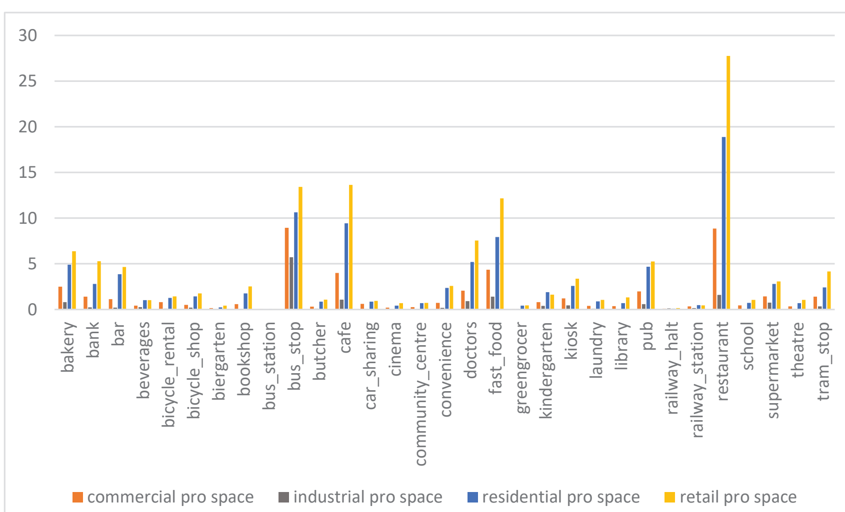

Figure 6. Average number of different POIs per coworking space in the vicinity of 500 m in the surrounding of coworking spaces in peripheral and non-peripheral areas compared with the category of land use where the coworking space is located.

For the 'bus_stop' POIs, the dwindling is not very dramatic. The number of the POIs shrinks from 13.4 in 'retail'-dominated locations, to 10.6 in 'residential', to 8.9 in 'commercial' and 5.7 in 'industrial'. POIs attributed to 'pub' are available in areas dominated by 'retail' and 'residential' nearly in the same amount (5.2 in 'retail' and 4.7 in 'residential'), but rarely in 'commercial' areas (2.0) and scarce in 'industrial' areas (0.6).

The regarded POIs seem to be dominant in areas with a high density of populations, such as residential areas or areas with a high number of people visiting, such as retail or commercial areas. That seems to be reasonable because these kinds of POIs need a large number of visitors and customers in order to be economically viable.

In Figure 7 (non-peripheral), all POIs are similar to Figure 6. The most available POIs in areas with a dominant land-use 'retail' are 'restaurant' (28.9), 'fast_food' (12.6), 'café' (13.5) and 'bus_stop' (13.2) in the vicinity. Compared with locations dominated by 'residential' land use, the number of POIs 'restaurant' is 22.2; in locations dominated by 'commercial' land use, the number of 'restaurant' POIs is 9.7; and in locations dominated by 'industrial' land use, the number of 'restaurant' POIs is only at 2.1.

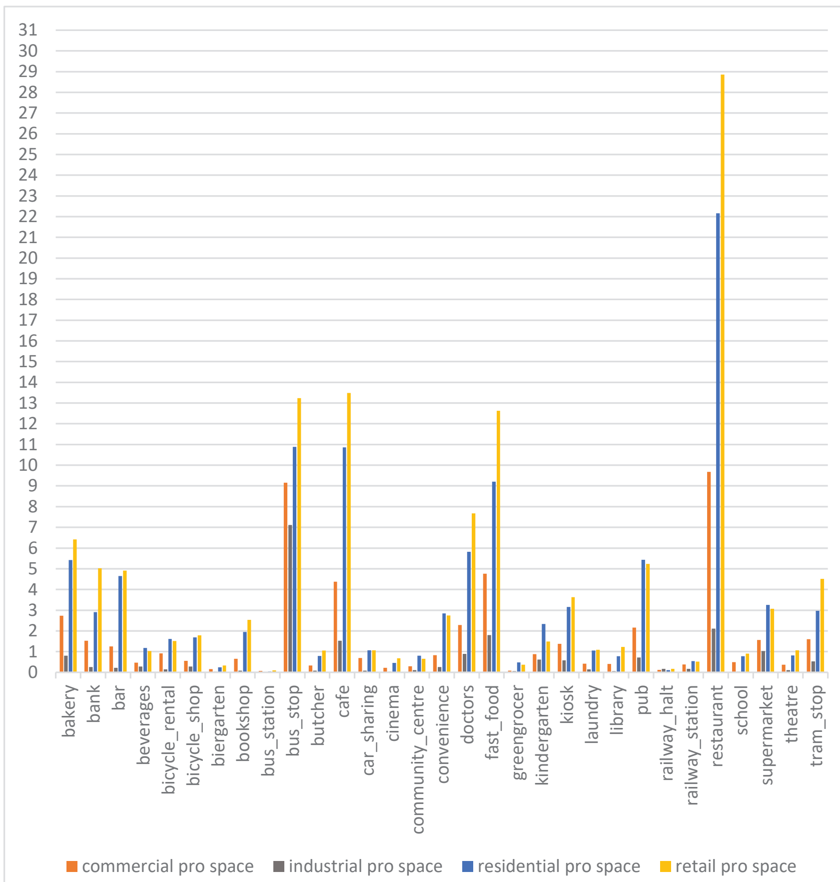

Figure 7. Average number of different POIs per coworking space in the vicinity of 500 m in the surrounding of coworking spaces in non-peripheral areas compared with the category of land use where the coworking space is located.

In Figure 8 (peripheral), all POIs are generally similarly distributed to Figure 7. The most available POIs in areas with a dominant land use 'retail' are 'restaurant' (19.8), 'fast_food' (8.8), 'café' (14.8) and 'bus_stop' (14.7) in the vicinity of CWSs (500 m). While the number of 'restaurant' and 'fast_food' POIs is significantly below average, in non-peripheral areas, the numbers of 'café' and 'bus_stop' POIs are above average in non-peripheral areas. Compared with locations dominated by 'residential' land use, the number of 'restaurant' POIs is 7.8; in locations dominated by 'commercial' land use, the number of 'restaurant' POIs is 2.5; and in locations dominated by 'industrial' land use, the number of 'restaurant' POIs is only 0.6.

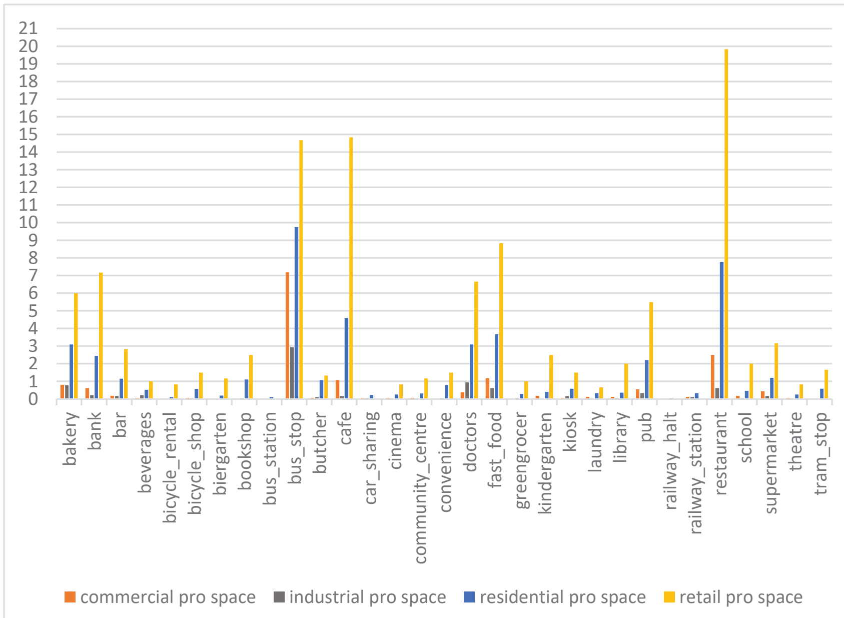

Figure 8. Average number of different POIs per coworking space in the vicinity of 500 m in the surrounding of coworking spaces in peripheral areas compared with the category of land use where the coworking space is located.

It seems that the that the POIs are distributed similarly, but with a more extreme distribution. This is probably due to the lower population density and more intensive car use in peripheral, rural regions, which makes it easier to travel longer distances between different functions in different areas.

To have a clear numerical comparison of the number of POIs which could be found in the vicinity of coworking spaces, we create the following table (Table 3), where small numbers, e.g., for bookshops in commercial and industrial areas, could also be recognized.

Table 3. List of the average quantity of POIs by land-use type related to peripheral and non-peripheral regions.

	Peripheral				Non-Peripheral			
	Commercial/Space	Industrial/Space	Residential/Space	Retail/Space	Commercial/Space	Industrial/Space	Residential/Space	Retail/Space
bakery	0.81	0.78	3.10	6.00	2.73	0.81	5.43	6.42
bank	0.63	0.22	2.45	7.17	1.52	0.25	2.91	5.02
bar	0.19	0.17	1.16	2.83	1.25	0.22	4.65	4.91
beverages	0.06	0.22	0.52	1.00	0.47	0.28	1.18	1.02
bicycle_rental	0.00	0.00	0.11	0.83	0.92	0.14	1.61	1.51
bicycle_shop	0.06	0.06	0.57	1.50	0.55	0.28	1.69	1.79
biergarten	0.00	0.00	0.19	1.17	0.16	0.03	0.24	0.33
bookshop	0.00	0.06	1.12	2.50	0.66	0.08	1.95	2.53
bus_station	0.00	0.00	0.11	0.00	0.07	0.00	0.04	0.09
bus_stop	7.19	2.94	9.75	14.67	9.16	7.11	10.89	1.23
butcher	0.06	0.11	1.07	1.33	0.34	0.08	0.80	1.05
café	1.06	0.17	4.58	14.83	4.38	1.53	10.86	13.49
car_sharing	0.06	0.06	0.22	0.00	0.70	0.08	1.07	1.07
cinema	0.06	0.00	0.26	0.83	0.22	0.03	0.46	0.67
community_centre	0.06	0.00	0.32	1.17	0.30	0.11	0.80	0.65
convenience	0.00	0.06	0.80	1.50	0.83	0.25	2.84	2.74
doctors	0.38	0.94	3.10	6.67	2.28	0.89	5.82	7.67
fast_food	1.19	0.61	3.67	8.83	4.76	1.81	9.20	12.63
greengrocer	0.00	0.06	0.29	1.00	0.08	0.06	0.48	0.37
kindergarten	0.19	0.00	0.41	2.50	0.88	0.61	2.33	1.49
kiosk	0.06	0.17	0.58	1.50	1.38	0.58	3.16	3.63
laundry	0.13	0.00	0.33	0.67	0.42	0.14	1.05	1.09
library	0.13	0.06	0.36	2.00	0.41	0.06	0.78	1.23
pub	0.56	0.33	2.19	5.50	2.16	0.72	5.43	5.23
railway_halt	0.00	0.00	0.06	0.00	0.12	0.17	0.11	0.16
railway_station	0.13	0.11	0.33	0.00	0.38	0.17	0.54	0.51
restaurant	2.50	0.61	7.77	19.83	9.67	2.11	22.17	28.86
school	0.19	0.06	0.47	2.00	0.50	0.03	0.78	0.91
supermarket	0.44	0.17	1.19	3.17	1.57	1.03	3.26	3.07
theatre	0.06	0.00	0.26	0.83	0.37	0.11	0.82	1.07
tram_stop	0.00	0.00	0.58	1.67	1.60	0.53	2.97	4.51

4.4. Mapping of CWS Locations and Land Use

The maps in Figures 9 and 10 (Munich), Figures 11 and 12 (Pfaffenhofen an der Ilm) illustrate the spreading and accumulation of POIs related to CWSs. These examples illustrate several aspects of our rather statistical investigation. On the one hand, it is apparent that CWS sites in large cities have a larger number of POIs in their surroundings, Figures 9 and 10 (Munich), and on the other hand, that land use also has an influence on the number of POIs—there are hardly any POIs in industrial areas, few in commercial areas, and many in residential areas (Figures 9–12).

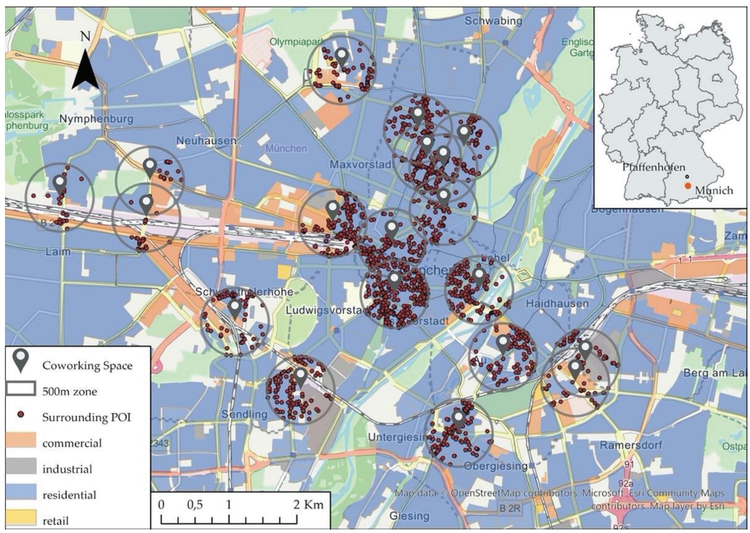

Figure 9. Map of POIs as listed in Table 2 in a radius of 500 m around coworking spaces (CWSs) in Munich (without scale), source: ArcGIS® software by Esri, OSM, gefabrik.de, coworkingmap.de, © GeoBasis-DE/BKG (2020).

Figure 10. Map of all POIs of the category 'pois_free' in Munich (without scale), source: ArcGIS® software by Esri, OSM, gefabrik.de, coworkingmap.de, © GeoBasis-DE/BKG (2020).

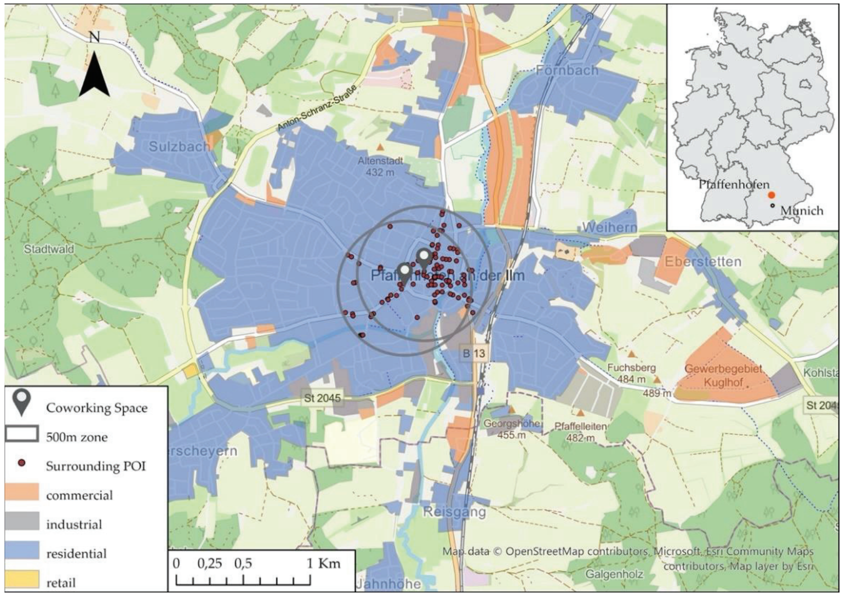

Figure 11. Map of POIs as listed in Table 2 in a radius of 500 m around coworking spaces (CWSs) in Pfaffenhofen an der Ilm (without scale) source: ArcGIS® software by Esri, OSM, gefabrik.de, coworkingmap.de, © GeoBasis-DE/BKG (2020).

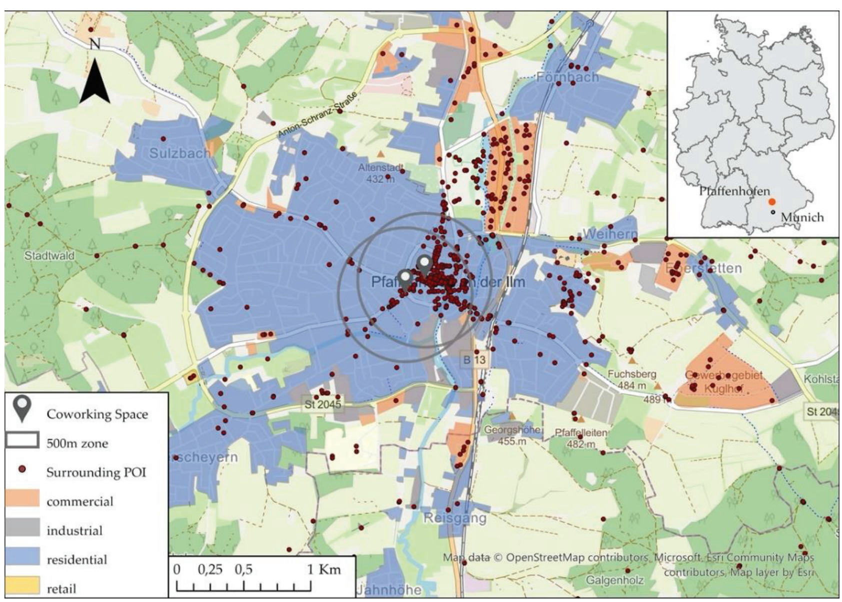

Figure 12. Map of all POIs of the category 'pois_free' in Pfaffenhofen an der Ilm (without scale) source: ArcGIS® software by Esri, OSM, gefabrik.de, coworkingmap.de, © GeoBasis-DE/BKG (2020).

4.5. Comparison of POIs in the Vicinity of CWSs to POIs in the Vicinity of Other Places of Work

As described above, we found a high number of POIs, which are relevant in the course of a regular working day, in the vicinity of coworking spaces, especially if they are located in non-peripheral regions and in areas that are dominated by residential or commercial land use. To compare this with other, more traditional locations of white-collar office work, we took a look at office locations in both of the regarded cities, Munich and Pfaffenhofen an der Ilm. For Munich, we chose the office city/city of offices Unterföhring, Dieselstraße (Figure 13), which is dominantly used as a location for offices, with companies as Allianz, ZDF, Pro7Sat1 (television broadcasting companies). For Pfaffenhofen an der Ilm, we chose the location of the company Hipp GmbH in Georg-Hipp-Straße (Figure 14), which is a huge and important employer in Pfaffenhofen an der Ilm. As coworking space, for example, we chose the coworking space EchtLand in Pfaffenhofen an der Ilm and MATES in Schwabing, Munich.

From Figures 13 and 14, we received a first impression of the number of POIs in the vicinity of the office locations. To obtain a clearer picture, we analysed the number of relevant POIs in the vicinity, again within a radius of 500 m.

By analysing the POIs in the vicinity of these different locations (Figures 15–18)—office cities, on the one hand (Figures 15 and 17) and, coworking spaces on the other hand (Figures 16 and 18)—we found in general a higher number of POIs close to the CWS, especially in non-peripheral regions (Figure 17).

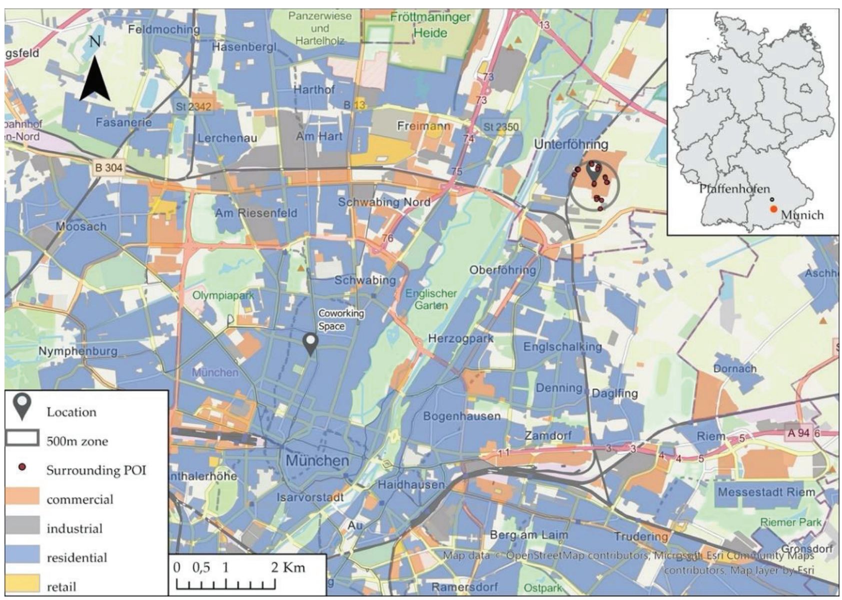

Figure 13. Map of all POIs in the category 'pois_free' in Unterföhring, Munich (without scale). Source: ArcGIS® software by Esri, OSM, gefabrik.de, coworkingmap.de, © GeoBasis-DE/BKG (2020).

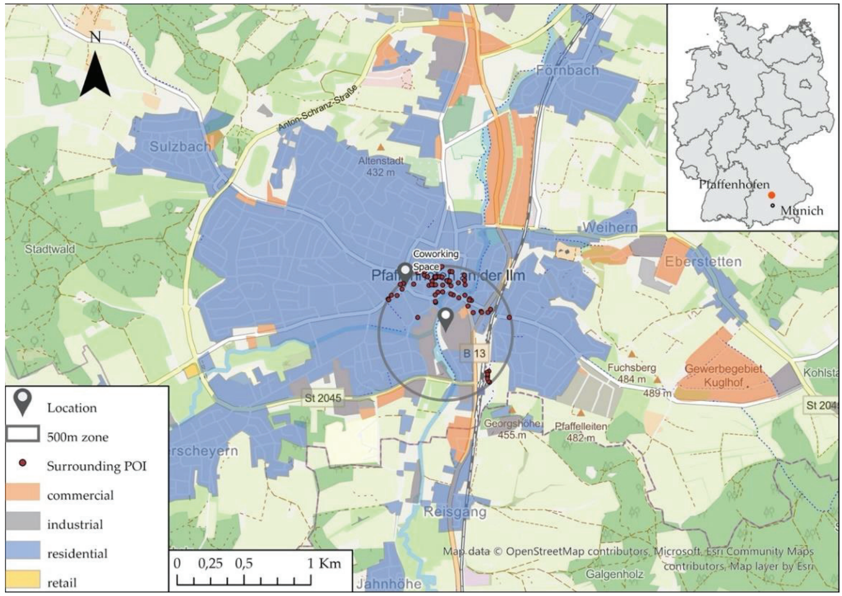

Figure 14. Map of all POIs of the category 'pois_free' in Pfaffenhofen an der Ilm, Georg-Hipp-Straße (without scale) source: ArcGIS® software by Esri, OSM, gefabrik.de, coworkingmap.de, © GeoBasis-DE/BKG (2020).

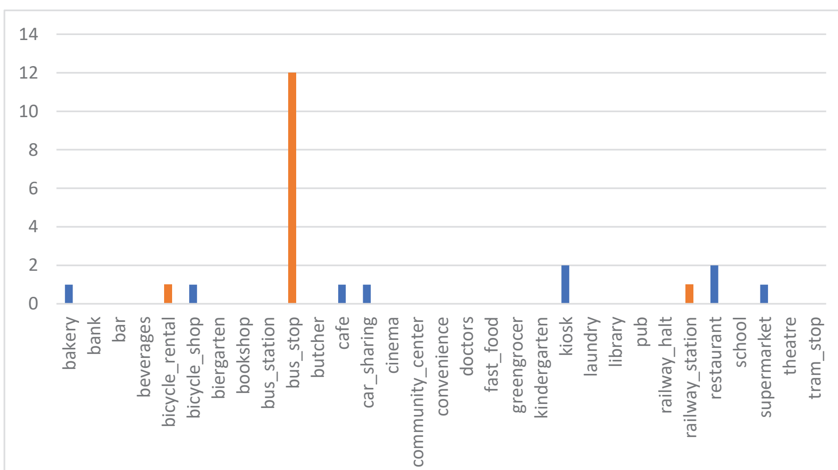

Figure 15. Number of POIs in the vicinity of 500 m in the surrounding of the office location Dieselstraße in Unterföhring, Munich.

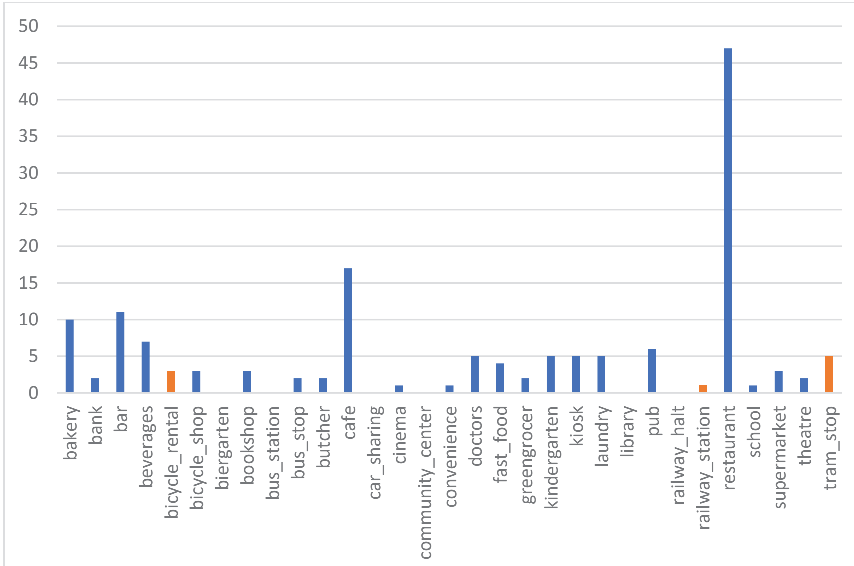

Figure 16. Number of POIs in the vicinity of 500 m in the surrounding of the CWS MATES in Schwabing, Munich.

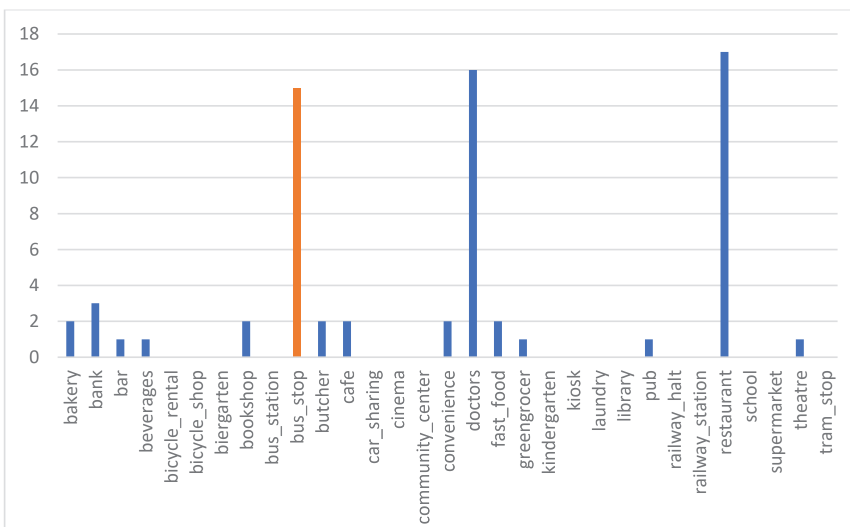

Figure 17. Number of POIs in the vicinity of 500 m in the surrounding of the company HIPP in Pfaffenhofen an der Ilm.

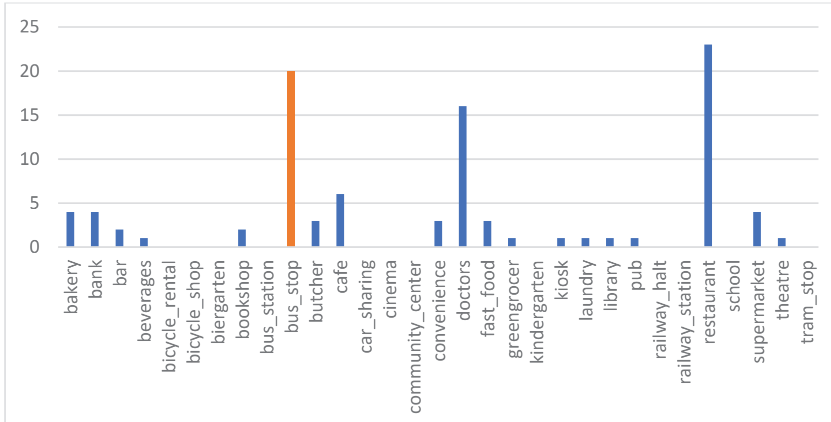

Figure 18. Number of POIs in the vicinity of 500 m in the surrounding of the CWS EchtLand in Pfaffenhofen an der Ilm.

The high number of "bus_stop" POIs in the vicinity of the companies, compared with the vicinity of CWSs, is noteworthy; furthermore, the number of POIs in general in the vicinity of Dieselstraße is more or less at the same level to the number of POIs in the vicinity of the company HIPP. It seems that CWSs are more likely to be located in a more urban, mixed-use surrounding, and also when they are located in a peripheral/rural region.

5. Discussion

5.1. Peripheral and Non-Peripheral Location of CWSs

The results demonstrate that the majority of coworking spaces (CWSs) represents tertiary work [106], non-physical work, knowledge-based work, creative work [63] or freelance work [67]. This type of work mainly occurs in non-peripheral regions (562 CWSs in non-peripheral areas—79%, 149 CWSs in peripheral areas—21%). Hereby, we employ the definition of non-peripheral areas according to Workgroup 1 of the COST action CA18214, as functional urban areas (FAU) below 200,000 inhabitants [131]. With this, we have an estimate of where coworking spaces are mainly located, which is still in non-peripheral, more urban environments.

This contradicts the findings in Italy, where the CWSs are in 76% of the cases in urban areas, in 5% of the cases in intermunicipal areas, in 16% of the cases in outlying areas, and in 3% of the cases in intermediate areas. CWSs apparently hardly exist in peripheral areas and ultra-peripheral areas [101].

In the last years—and presumably fuelled by the COVID-19 pandemic and the increase in remote work—the benefits and spread of CWSs in rural regions have been widely discussed [80,96,97] and politically supported [84–86]. The type of location where CWSs are located seems to depend on their concept, e.g., Retreat, Coworkation, Commuter Port, etc. [80]. With political support [86] and possible funding [82], it can be assumed that the spread of CWSs in peripheral regions will increase.

5.2. Location of CWSs and Land Use

The above-described analysis gives only a very rough cognition, where coworking spaces are located. With the land-use classification from the OSM dataset, we can identify the dominating use of the neighbourhood in which a coworking space is located. Here, we found a dominance of CWS locations in 'residential' neighbourhood by 63% in general related to other kind of land use. There is a dominance of 'residential' land use of 62% in non-peripheral and a higher share of 69% 'residential' land use in peripheral regions. Residential neighbourhoods provide a high nearby potential of users or customers for

CWSs and for other amenities, offers and services (POIs) [49]. A spatial close relationship between POIs with each other and with CWSs makes it more likely that multipurpose trips will be taken [127,128].

While in non-peripheral regions, the share of CWSs located in 'commercial' neighbourhoods is at 22% and for 'industrial' areas at 6%. In non-peripheral neighbourhoods, the share of CWSs in 'commercial' neighbourhoods is at 11% and for 'industrial' at 12%, which doubles the result compared to non-peripheral locations. The higher share of CWSs located in 'industrial' neighbourhoods remote from—or not inside of—'residential' neighbourhoods makes it more likely that people—users or tenants of CWSs—will travel to work by car, due to the higher distance [22] and the time saving and faster mode of transport by car. The separation of town districts by function as it was proposed by the idea of "Garden City" [12] and the "Charter of Athens" [27]—which were reasonable in previous times—leads to a higher average distance between the place of work, residence and other destinations—in our research, the regarded CWSs and POIs.

If commuting to the regular—not necessarily daily—place where work is performed is by car, it is more probable that other daily trips, such as going to buy groceries, going to sports or recreation facilities, is carried out by car as well [127]. This will inevitably lead to a higher number of car trips, which is more evident in peripheral regions, where the distances for daily trips are higher [22]. If a CWS is located in an industrially or commercially dominated area, it is also more likely that people continue to rely on car transport for daily trips. For the environment, this would lead to higher emissions of CO_2/greenhouse gases, and for infrastructure planning, this would ultimately lead to higher demands for parking and road space as well as higher costs for road maintenance. Such a development is contra-effective for the goals of sustainable transport (as recommended by the United Nations Secretary-General's High-Level Advisory Group [46]), Sustainability Strategy of Germany [47], the National Platform Future of Mobility [48], and the concept of the 15-Minute City [118].

The 'New Leipzig Charter' planning policies adopted on a national level [47,86] and EU level formulate the aim D.1.1 Active and strategic land policy and land use planning "Polycentric settlement structures with appropriate compactness and density in urban and rural areas with optimal connections within cities to minimise distances between housing, work, leisure, education, local shops and services" [121].

Strategies that take this focus on vicinity into account have not been implemented much so far; more traditional functionally separate structures, which are legally specified by the framework (BauNVO), are adopted by municipalities as land-use plans. Hereby, the land consumption often exceeds the population growth [115].

If a CWS is located in the centre of a town or village, it could give an abandoned house or shop a new assignment; maintain the already built grey energy; bring vividness and spending capacity to the traditional town centre, with amenities, shop, services (POIs); and prevent people from driving to the outskirts by car. Admittedly, this is not guaranteed, but it is more likely if it is more attractive. Following the New Leipzig Charter and regarding our findings on the relevance of vicinity, the functional separation of land use through the BauNVO should be questioned.

From a legal perspective, a CWS can also be approved in residential, retail, industrial or commercial areas, in which CWSs can also be found. In residential areas, there is a higher number of different uses and diversity recognizable in the higher number of POIs. This grade of diversity seems to be more attractive for CWSs as there can be more CWSs. The diversity of city districts is what Jacobs was aiming at 60 years ago. The Charter of Athens and the BauNVO ultimately prevents city districts from being diverse, i.e., having different uses, not allowing only certain uses and excluding non-listed uses, for the BauNVO [32]. The regulations of the BauNVO closely connected to how the Charter of Athens approaches the separation of uses. The Charter of Athens relies on the idea of the Garden City with functionally separated districts [32]. Additionally, 60 years ago, Jane Jacobs promoted pedestrian-friendly cities [53], which is currently taken up in the New Leipzig Charter or the 15-Minute City. Such a pedestrian-friendly city district could generate residential areas with a high number of POIs and thereby a diverse range of amenities, offers and services. Those amenities in residential areas attract more CWSs than in other areas.

5.3. POIs and Their Spatial Relation to Coworking Spaces

The sample of daily trips consists of work-related and more private occasions, with nearly one-third being related to education and work, one-third to trips for leisure issues, and one-third to shopping and private errands [22]. If work is performed in a coworking space is relevant, if there are destinations for other purposes, as mentioned above, close to the CWS, to combine the trip to or from the place of work with the trip to or from the coworking space [127].

The POIs we have chosen and listed in Table 2 can be regarded as potentially related or combinable with the trip from or to the place of work. Due to the relationship between the place of work and the listed destinations, the spatial proximities of the place of work and other daily destinations are indicators for a relevant accessibility of these, especially when they are in easy walkable distance of maximum 500 m (5.7–6.4 min) [124].

From the regarded POIs classes (Table 2), in total ca. 700,000, nearly one-twentieth is located in the 500 m radius around CWSs. Around 88% of this share is located in the 500 m radius around CWSs in non-peripheral regions. The density of POIs in non-peripheral regions is much higher than in peripheral regions, which can be assumed.

Taking a general view on peripheral and non-peripheral regions, we found a high share of POIs 'bus_stop' (8.1), 'café' (7), 'fast_food' (6.2) and 'restaurant' (14) in the 500 m vicinity of an average coworking space. The numbers are higher in non-peripheral and lower in peripheral regions, reasoned in the general difference of POI density. The higher density of relevant POIs in non-peripheral regions was expected, but it underlines the relevance of a high number of POIs spatially related to the place of work [127,128].

When we separated our consideration of the type of land use, we found a clear spreading of POIs between the categories 'retail', 'residential', 'commercial' and 'industrial'. It should be noted here that 'retail' can be both inner-city locations and shopping centres on the outskirts of settlements.

The POI 'restaurant' seems to be relevant as an option to buy lunch during the course of the day and take a break from work. Regarding the number of 'restaurant' POIs in non-peripheral regions, in the land-use categories, we found an average of 28.9 in 'retail', 22.2 in 'residential', 9.7 in 'commercial' and 2.1 'industrial'. The availability and range of offers is high in 'retail' and 'residential' areas and attractive as a location for a coworking space, which seldom have their own lunch service.

Regarding other highly relevant destinations for daily or regular trips [119], we take a closer look at the POIs 'supermarket' and 'kindergarten'. In non-peripheral regions, we found 3.1 'supermarket' POIs in 'retail' areas, 3.3 in 'residential' areas, 1.6 in 'commercial' areas and 1.0 in 'industrial' areas 500 m around a coworking space.

In peripheral regions, the situation deviates outside of 'retail' areas. Here, we found 3.2 'supermarket' POIs in 'retail' areas, only 1.2 in 'residential' areas, only 0.4 in 'commercial' areas and 0.2 in 'industrial' areas 500 m around a coworking space. We found a slightly higher number of 'supermarket' POIs in 'retail' areas in peripheral regions, and in non-peripheral regions, a massive drop in 'supermarket' POIs in 'residential', 'commercial' and 'industrial' areas 500 m around a coworking space.

In non-peripheral regions, we found 1.5 'kindergarten POIs in 'retail' areas, 2.3 in 'residential' areas, 0.8 in 'commercial' areas and 0.6 in 'industrial' areas 500 m around a coworking space. In peripheral regions, we found 2.5 'kindergarten' POIs in 'retail' areas, 0.4 in 'residential' areas, 0.2 in 'commercial' areas and 0 in 'industrial' areas 500 m around a coworking space. The availability of a kindergarten should be more important in a residential area than in an industrial area, which reflects our findings. It is interesting to note that in peripheral regions, the value for retail areas is higher than for residential areas. This could be due to the small-scale character of rural towns, where central areas are more likely to be attributed to shopping areas. However, this is not the case for our sample communities and should be considered further in future research.

It seems to be significant that CWSs in peripheral areas have more POIs in their vicinity than in non-peripheral areas. This suggests that one could potentially increase the attractiveness of CWSs in non-peripheral regions by increasing the number of POIs (Figure 16).

It is, however, important to note here that a high number of POIs need to be relevant for daily use, as indicated by the list in Table 2. In this way, it is possible to combine necessary trips with the trip to the job, and to reduce the commuting time, avoid traffic jams, decrease CO_2 emissions, and support the local economy. CWSs and other amenities represented by POIs such as shops and services can benefit from each other. On the one hand, the presence of CWSs enables the increase in potential users of CWSs to utilise the services of POIs. On the other hand, users of a CWS bring purchasing power and customer frequency to the offers in the vicinity of the CWS. In addition to the benefits for users, POIs also offer the opportunity for cooperation and networking, not only within the CWS but also with the neighbouring POIs [81,90]. CWSs and POIs, e.g., restaurants, shops, cafés, and cultural institutions, could cooperate, enrich the respective offerings and provide opportunities for network expansion.

With a higher visitor frequency, decaying inner towns could gain vitality and avoid or reduce the donut effect [60,61].

6. Limitations

Although the findings of this research have generated a first insight into the spatial and thematic relations between the place of work and the place of residence as well as the essence of why and how people use coworking spaces, we also realise that the research approach was not without limitations. First of all, we had to rely on open-source data, which may not have been validated at all times. Secondly, we made a number of assumptions in our modelling, such as walkability distance. Obviously, such distances could be further detailed with topographic height and steepness information, for example, complemented by pedestrian surveys to test the degree of walkability or carry out an accessibility analysis with routing algorithms using a topological, routable road network in GIS. However, this was not the main purpose of this specific study. The first step was to find general trends on spatial relations and finding relevant indicators. Thirdly, one could also debate the choice of POIs. The large variation in identified POIs of specific land-uses between peripheral and non-peripheral regions suggests that the land uses recorded in the OSM database are less comprehensive and precise, at least in more rural areas. We found that the geocoded locations of CWSs in ArcGIS based on the address can produce deviations in a few cases.

With more cases of coworking spaces in and outside of Germany, the picture we produced with our research could be improved and maybe generalised. This could provide more insight into the consistency of results. Constructing detailed spatial models to carry out simulations could predict future developments. Results could be validated by remote sensing in order to find whether one can detect, and possibly automate, the dynamic relations between work and residence. Surveys on the behaviour of users, tenants and operators of CWSs could give a clearer picture of changes in the course of the day and usage in time, money and presence.

We excluded 12 CWSs from our research because they have no POIs in their vicinity. Reasons for the lack of POIs could be the remoteness of these CWSs. This could be the case for CWSs that are used more for retreats or 'workations' [80]. The background could be further explored in future studies.

Even if the frequency of specific POIs is particularly high in the vicinity of CWSs, by our judgement, no explicit requirement for a specific POI can be identified. The higher frequency of POIs only seems to make a location attractive for CWSs in principle, as they occur more frequently here. However, this study cannot make any statement about the economic success and thus the long-term existence of the CWS.

A closer look at prototypes of CWSs in further research could investigate in specific circumstances, activities, business models, etc.

7. Conclusions

The spatial analysis of POIs in relation to the location of coworking spaces confirms that coworking spaces are more likely to be located in non-peripheral areas than in peripheral areas. In fact, our findings reveal that 79% of the examined cases were located in non-peripheral areas and 21% in peripheral areas. However, the review of the variety of services and the connection of this variety of services to CWSs reveals novel insights in the discourses so far.

First of all, the vicinity of CWSs can be described in 62% of the cases as residential, 22% as commercial, 6% as industrial, and 8% as retail for non-peripheral CWSs. In contrast, for peripheral areas, the vicinity reflects a surrounding which is in 69% of the cases residential, 11% commercial, 12% industrial, and 4% retail. Hence, in non-peripheral areas, there is a larger variety and more balanced distribution of services in the vicinity of the CWS, suggesting that the more peripheral an area is, the more variety and more equal distribution there may be. Secondly, there is a clear relationship between the types of services and the attractiveness of CWSs.

A CWS is more attractive if it has easy access to a high number of relevant POIs. This implies that when launching a CWS, one has to take both the variety and type of additional services into account.

Thirdly, an important consequence of establishing vibrant CWSs is that it may create and foster local vitality and versatility in the region and contribute to a more attractive quality of life. There is still a separation between private life and working life, yet this separation is relatively small in terms of time and distance. The direct effect is that the number of trips can be reduced drastically, but an indirect effect is that being more engaged in a certain surrounding will also have an impact on the sense of belonging and identity. This fuels the allocation of spending capacity in the vicinity of CWSs, enhancing lifelines and vitality of the public space surrounding the CWSs, which should be located in the inner-town. This is even more important in rural regions, where distances and daily trips are usually longer than into non-peripheral regions and urban areas.

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Challenges for Social Participation in Conservation in the Biocultural Landscape Area in the Western Sierra of Jalisco

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Abstract: The protection of biocultural heritage has generated alternative proposals for the conservation of rural areas. Varied organizations collaborate in a pioneering conservation model, the Biocultural Landscape (BL), where local participation is paramount, that operates in the Western Sierra of Jalisco. The objective of this work was to analyze social participation, conditions, and characteristics of the model based on the WWF and IUCN guidelines. Information about the context, management, and planning was collected and synthesized. The data of territorial management, conservation, knowledge, and local conflicts about participatory processes were collected from 12 stakeholders and analyzed with ATLAS.ti software. It was found that, although local people are familiar with the concept of the protected natural area and the BL model, they cannot clearly identify its objective. The most informed are the interested population that collaborates closely. There are conflicts of interest between those who collaborate directly with the BL and those who do not, which have been resolved through the active participation of the different levels of government and experts who have intervened as mediators. Environmental awareness about the importance of conservation has been achieved by integrating the communities. Given that it is not a restrictive protection model and the rules were created in conjunction with the community, local participation is encouraged.

Keywords: biocultural; social participation; natural protected area; conservation

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1. Introduction

Despite advances in conservation, multiple challenges are being faced around the world to achieve it, and alternatives are being sought where society and government join efforts to accelerate and ensure the process that leads to sustainable use of natural resources. However, in a world dominated by a western view, where humans are not part of nature but above it, conservation achievements are limited even in protected natural areas. Some have concluded that, to date, protected areas around the world often fail in the aim of achieving ecosystem conservation and of improving local people's wellbeing [1]. This has made necessary other forms of conservation and management of nature [2], which could be considered innovative. Understanding the characteristics of the interdependent society–nature relationship is necessary to achieve conservation, which is manifested through values, symbols, and worldviews [3]. The organization, functioning, vitality, and resilience of ecosystems and human communities are mutually linked, a fact that has been recognized since the 1990s by various authors [4], which implies the diversity of life in all its manifestations, biological as well as cultural and linguistic, related in a complex way in an adaptive socio-ecological system.

Although there is debate about the biocultural concept, Lindholm and Ekblom [5] established that the understanding of cultural landscapes is the result of long-term biological and social relationships, which shape the biological and material characteristics of the landscape as well as memory, experience, and knowledge. Biocultural diversity denotes the diversity of life in its multiple manifestations: biological, cultural, and linguistic, framed in sociocultural systems [6]. The interdependence between biological and cultural diversity has been developed over time through adaptive processes [7], and the rapid loss of both around the world has led to a concern about its effects on the achievement of sustainability objectives [8]. Social participation is, then, required to achieve conservation, and designing natural protected areas is one of the common strategies for biological and cultural conservation. However, there is evidence that the limited participation of local populations in conservation proposals generates conflict. On the other hand, participation increases the credibility of government authorities, reduces potential conflicts between the parties, improves the quality and quantity of information that flows better in the system, reduces the power of some dominant actors, and improves the decision-making process [9]. Given the limited achievements of participation in environmental governance, rather than focusing on improving the participatory process, some authors tried to understand its failures and concluded that the institutional and political context is a determining factor and includes the provisions for participation in the directives, lack of policy integration, and lack of political assimilation of the results of participation [10].

Generally, the topic of social participation in works on natural protected areas is scarce and addresses issues about the influence of local governments, the limited participation of communities, and conservation as a conflictive issue [11–13].

Even when the concept "biocultural" is not used as associated with landscape and related to natural protected areas, it is always implicit. There are examples where natural and cultural heritage are considered with the same importance. In Slovakia, the agricultural landscape was studied related to the wine-growing landscape, herbaceous-pastoral landscape, and livestock landscape, and concluded that the participation of the local population has been fundamental as a source of information and management in the concern for the extinction of agricultural landscapes [14]. In the Netherlands, measures related to biocultural have been relevant for the management of natural parks and the increase of local participation [15] in areas such as nature conservation, including individual and collective activities related to studies, training of guides, and volunteers and recreative activities related to nature.

Agriculture has been relevant to the biocultural issue due to its centuries-old practices that are now focused on sustainable activities and in some countries such as Morocco, these sites have been considered World Heritage Sites by UNESCO and part of the MAB program [15,16].

As in many places in the world, natural protected areas in Mexico face various problems, such as uncoordinated public policies, local conflicts due to the use and control of natural resources, exclusion of community participation, and damage to populations for obtaining their economic livelihood [17–20]. These complications result in the need to generate strategies according to the characteristics of the territory, in favor of local integration and the protection of the biocultural heritage. These are crucial for the proper functioning of the territory and appeal to a complex socio-ecological vision that entails learning and collaboration with a large number of actors in a region [21–23].

The French and Mexican governments explored the possibility of adapting local governance schemes that would support biological and cultural diversity conservation work in Mexico promoting sustainable rural development. This was done through the adaptation of the French Regional Natural Park model [24] that would give rise to the figure of BP in Mexico as an innovative model of territorial valorization [25].

In the western Sierra of Jalisco in Mexico this regional model was called BL, whose challenge is to achieve conservation in a broad sense through sustainable development and where some questions arise: Does this model surpass the traditional model of protected natural areas implemented by governments? What challenges does it face related to social participation? In this context, the model and its characteristics in the State of Jalisco in Mexico are described below.

1.1. Biocultural Landscape Model and Local Participation

The interest in the rural world, in the face of the failure of top-down development models, led to the emergence in the 1990s of the community initiative known as LEADER, based on a territorial approach, the creation of new participatory local government structures, and decentralized management [26].

The European Landscape Convention was the first international convention focused on this issue, derived from the concern to achieve sustainable development based on a balanced relationship between social needs, the economy, and the environment, thus, a central element of the quality of life of human populations [27]. In this context, a predecessor of the BL can be considered the IUCN category V Landscape, unique among the different categories due to its emphasis on people–nature interaction, which recognized the need to design areas which were different from those subject to strict protection, but were also economically, socially, culturally, and environmentally important. This category considers support for human communities and the sustainable use of natural resources, which has been important for developing countries facing problems of poverty and protection of local culture and nature, especially in rural communities [28].

Given the various conflicts associated with protected natural areas and the participation of local populations, the BL is a territory recognized for its biocultural and landscape value, in which all stakeholders (government and inhabitants) collaborate synergistically around a concerted sustainable development project through which, as result of protection and valorization of the biocultural heritage, economic development is promoted [29]. Territorial management is defined and adopted by municipal governments, the state, federal governments, and the representative bodies of social groups involved. Its main virtue is the active participation of local actors, mainly producers and traders, as well as support for the conservation of natural areas by the communities' own decisions and not due to a decree made by outside interests. Sustainable resource management is sought in the area to strengthen governance mechanisms, financing processes, and productive chains and to support the institutionalization of governance in the territory through local production [30]. The region provides environmental services to local communities as well as food, commercial products, climate, cultural, and tourism services.

The BL model is a Mexican proposal of governance [24] that bases its operation on a Territorial Management Agreement which generally reflects the development aspirations of a region, aspirations which were collected in various ways and have three main orientations: (1) Environment and territory; (2) Society and culture; and (3) Economy and solidarity [31]. For the first, the aspiration is that inhabitants and various socio-productive sectors preserve biodiversity, goods, and services provided by the natural environment. Related to society and culture, the inhabitants, visitors, and diverse socio-productive sectors recognize and value their cultural heritage and territorial identity, recovering and using their traditional knowledge. The third states that production systems are sustainably developed and managed to ensure equity and justice in institutional, commercial, and environmental relations.

Each orientation has axes and involves measures, provisions, and actions that also have transverse orientations that encourage the achievement of each of the axes: Capacity building; Collaborative and differentiated management for all; Education, linkage, and research. It can be assumed that this would be the framework for stakeholder participation and interaction with the territory in question, which, unlike conventional natural protected areas, generally lacks prior agreement and a common vision.

The model has been publicized as successful and as a mechanism for sustainable territorial management, based on social participation, which is a key aspect of territorial governance, both for the sustainable use of resources and for improving living conditions. However, this conception of management has been questioned as it is considered an "emerging form of social control under the premise of participation" ([20], p. 214) that can lead to the homogenization of socio-cultural differences in the long term.

A new question arises at this point: has the model succeeded in improving participation to achieve conservation objectives in the Western Sierra of Jalisco? We hypothesized that the BL model has improved social participation, unlike traditional natural protected areas generally designed by governments which linearly and hierarchically exclude local participation.

1.2. Study Area

The BL area of 245,000 hectares partially encompasses four rural municipalities in the Western Sierra of Jalisco under a voluntary state conservation decree: San Sebastián del Oeste, Mascota, Talpa de Allende, and Atenguillo (Figure 1). The first three are home to "Magical Towns", which is the name of a federal program that recognizes their tourism value related to their natural and cultural heritage.

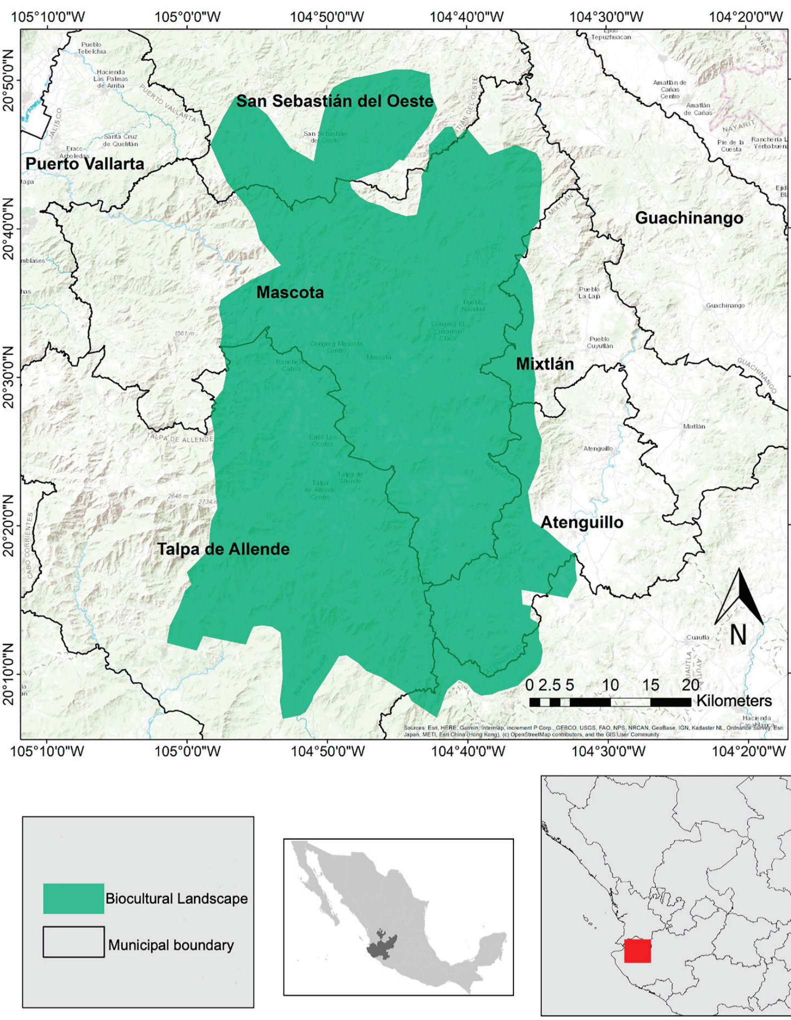

Figure 1. Geographical location of the Biocultural Landscape area at Western Sierra (in red) of Jalisco (in gray).

The total population in BL is 31,786, where the main economic activities are based on agriculture, cattle ranching, commerce and tourism. [32–35].

The natural heritage of this region is made up of mountains (64%) whose maximum altitude is 2760 m above sea level and which form an important hydrological basin that drains into the Pacific. The main land uses are (a) flora and fauna, dominated by maple and pine-oak forests with species such as white-tailed deer and jaguar, occupying 42.1% of the region's total area; (b) forestry (28.26%); (c) natural area (17.47%); (d) agriculture (11.21%); (e) tourism (0.71%); and (f) human settlements (0.24%) [36]. The cultural heritage is represented by archeological vestiges, religious constructions, pilgrimages, and mines [37–39].

2. Methods

2.1. Evaluation of the Study Area

The BL area was evaluated for its context, management and planning according to IUCN's World Commission for Protected Areas (WCPA) and World Wildlife Fund (WWF) tool to track the management effectiveness of protected areas [40,41]. It is a framework to guide the assessment systems and the dissemination of results based on the premise that the good management of protected areas would be the product of a process that includes the analysis of the context of existing values and threats, the revision of the planning and allocation of resources (inputs), management actions (processes) and the eventual production of services and goods (products). A questionnaire with 20 items was adapted to the BL model as a guide to interview those in charge of the BL area, who also provided documents to demonstrate the arguments.

Two sections were included; the first contains information on the characteristics and design of the BL including status, regulations, laws, objectives, management plans, and natural characteristics. One of the items in this section requires a comment on critical habitat/ecosystems. This refers to areas that present particular conditions for the survival of a species or population and, so, require special management and protection. The second section evaluated infrastructure and participation, economic aspects, facilities, human capital, education, and local participation. Their comments on each item in both sectors were synthesized and then analyzed separately in a matrix, where the staff in charge expressed their opinions.

2.2. Stakeholders in the BL Model

As part of the second stage, 12 key stakeholders related to the BL, whose participation was considered indispensable and mandatory to achieve its purposes and goals, were identified [42]. Stakeholders are understood here as individuals who represent different groups that can affect the achievement of the objectives of the BL as an organization or who are affected by the achievement of its objectives [43].

The steps followed for the identification of key stakeholders were:

1. Collecting of information from key stakeholders that could be directly or indirectly related to the project (field and desk work).
2. Design of a database of key stakeholders according to local, municipal, and state levels.
3. Analysis of the interaction between stakeholders.
4. Stakeholder mapping.
5. Initiation of outreach, communication, and intervention strategies.

The resulting selected stakeholders represent local governments related to tourism and the environment, culture, academic, and commerce activity who were interviewed during the period of June 2019 to March 2020. The first contact was through the staff responsible for BL management and with a chain sampling including local and regional actors related to the BL area of the four municipalities, respecting the diversity of roles in the area (Table 1).

Table 1. Roles of the interviewed actors.

Actors	Role
1	Municipal government official (tourism sector)
2	BL staff
3	Local artisan
4	Municipal government official (tourism sector)
5	Local representative of state environmental institution
6	Municipal government official (culture and tourism)
7	Municipal government official (ecology)
8	Local merchant
9	BL staff
10	Municipal government official (ecology)
11	Academic
12	BL staff

The interview included 14 open questions and was structured considering the themes of territorial management, conservation, knowledge, and local conflicts about participatory processes between the local population and natural protected areas. The results were processed with ATLAS.ti v8 software; 33 categories (codes) were created and distributed into three groups: local conflicts (6), conservation and knowledge (11) and territorial management (16). Each code represents a label assigned to a response, which contains information on the topic addressed by the code group. Subsequently, responses with common themes were described.

3. Results

3.1. Characteristics and Design of the Biocultural Landscape Area in the Western Sierra of Jalisco

Context: Evaluation of the area states that the territory designed as BL is in process of recognition by the government because the actual environmental legislation in Mexico does not include a protected area with those characteristics. The existing mechanisms and rules are established in a document called "Territorial Chart" that functions like a management program for a natural protected area and where regulations and norms are described as well as a monitoring of the goals, plans, and results of the BL. Increased operational capacity could improve the implementation of legislation. This is a legal issue and amendments to the law are expected. Although the area is not physically demarcated, the boundaries are known, but work is underway to install infrastructure that will allow local people and visitors to know where the area is located and where to go. Given that it is an area of biological importance, there is some knowledge of the ecosystems included, but not enough (Table 2).

Management: The area has a high conservation value due to its ecosystem composition. The value of the territory is a function of connectivity with other areas in the region such as Manantlán, Cacoma, and Sierra de Vallejo. The most important function is connectivity between ecosystems because it allows the passage of certain species that require a wide space to move around (Table 2).

Planning: The objectives are set out in the "Territorial Chart" and foreseen for a 15-year period; the orientations and strategies to be followed are determined, and they are socialized with the socio-productive. Its approach and characteristics are favorable, as the conservation objectives promote sustainable land management. Currently, it is being analyzed and receiving feedback before it is approved and validated. An operative annual plan is elaborated each year and the BL council approves it. With respect to a monitoring plan, the current monitoring scheme and the information generated can be further utilized (Table 2).

Table 2. Assessment of the characteristics and design of the protected area (based on WCPA and WWF [40,41].

Evaluation Element	Subject	Selected Criterion
Context	Legal status *Does the protected area have legal status?*	No legal protected area decree
	Area regulations *Are unsuitable land uses and activities controlled?*	Although there are mechanisms to control land uses and activities, there are limitations to their effective implementation
	Application of regulations *Are the regulations being applied satisfactorily?*	Staff have acceptable capacity to implement legislation and regulations.
	Demarcation of territorial boundaries *Is the location of the boundaries known, and were they delineated in the field?*	Authorities know the area boundaries, but local people just know the approximate limits of the BL territory
	Natural resources inventory *Is there sufficient information for the management of the area?*	Available information on critical habitats, species, and cultural values are insufficient to support planning and decision-making processes
Planning	Objectives of the area *Are there established objectives?*	The area is being managed to achieve the objectives
	Design and extent of the area *Is there a need to increase the area or implement biological corridors to achieve the objectives?*	The design of the area is suitable for the achievement of the primary objectives.
	Management plan *Is there a management plan? Is it being implemented?*	There is a management plan
	Annual operative plan *Is there an annual work plan?*	There is a working plan and activities are monitored against set targets. A high proportion of them are fulfilled
	Monitoring and evaluation *Is there a research and monitoring program oriented towards the management of the area?*	There is an agreed monitoring and evaluation system in place, but the results are not systematically used for management.
Management	Biological importance: species	The area has few rare, threatened, or endangered species
	Biological importance: critical function habitat.	The protected area provides a habitat with a medium critical function

3.2. Infrastructure and Participation in the Protected Area

Inputs: Although in the study area there are adequately trained personnel for the tasks entrusted to them, more personnel are needed, mainly in the accompaniment of the projects and local actors according to their profiles. The budget is sufficient to maintain the required operating capacity. The financing of the activities is supplemented by external financing from public and private, national, and foreign organizations (Table 3).

Processes: Related to the local populations and BL, there is communication, although it is not the strongest. Activities are carried out related to tourism, so they are followed up with local providers. There is a need to improve conditions for the tourism sector (Table 3).

Products: Infrastructure and services are appropriate to the current visitation levels but can be improved. It is necessary to have better defined and signposted routes, and to order some massive activities (Table 3).

The area comprising the BL provides a medium critical function habitat and is comprised of ecosystems that are less affected. The current budget is sufficient to meet all management needs and there is adequate and effective equipment and infrastructure for the current levels of visitation but there is room for further improvement. No fee is required to enter and there is a significant economic benefit to the local communities.

Table 3. Infrastructure assessment and participation based on WCPA & WWF [40,41].

Evaluation Element	Subject	Selected Criterion
Inputs	Staff *Is there sufficient staff to manage the protected area?*	The quantity of staff is insufficient for critical management activities
	Training *Is there sufficient training for the staff?*	Staff training and skills are adequate for current challenges and future management
	Annual budget *Is the current budget sufficient to manage the area?*	The current budget is sufficient to meet management needs
Processes	Education program *Is there a planned program of education?*	There is a planned education and awareness program, but there are uncovered thematic and territorial areas
	Protected area and neighbors' relationships *Is there cooperation with the neighbors of the protected area?*	Communication and cooperation between BL staff and the nearby property owners is desirable and positive
	Local communities *Do the local communities (internal and external to the area) have access to decision making?*	The local communities participate directly in decision-making on the management of the protected area
	Tourism operators *Do tourism operators contribute to the management of the protected area?*	There is excellent cooperation between staff and the tourism sector to improve the visitor experience, protect the cultural and natural values of the area, and resolve conflicts
Products	Infrastructure for visitors ***Is the infrastructure for visitors (tourists, pilgrims, etc.) sufficient?***	Infrastructure and services are appropriate to the current visitation levels but can be improved

3.3. Biocultural Landscape Model Stakeholder Interviews

Stakeholders mentioned that while most people know what a protected area is, the opposite is true for the BL area. In both cases there are perceptions that may differ from the correct ones. Even so, it is common knowledge that the protection of natural resources is important for the community. Among other relevant points, local stakeholders agree that there is little community participation and that decreeing certain territories as natural protected areas can generate conflicts or negative or positive consequences. It is stated that limitations in the use of natural resources, power scales, and individual interests are aspects that influence local heritage protection issues (Table 4).

Table 4. Type of response by theme related to BL.

Theme/Question	Agree	Disagree	Both
1—Knowledge about what a natural protected area is	58%	42%	
2—Knowledge of what the BL model is	42%	58%	
3—Consider the protection of natural resources important for the community	100%		
4—There is government influence in the BL (positive or negative)	67%	25%	8%
5—The local participation in the BL planning processes is scarce	58%	34%	8%
6—There are negative consequences of natural resource protection decrees	50%	26%	24%
7—Economic alternatives are scarce in places where natural resources are protected by decree	26%	74%	
8—Natural resources, ecosystems, and biodiversity conservation generates conflicts between actors	66%	26%	8%
9— Political actors make decisions without the participation of the local community	66%	34%	
10—The scale of powers among local actors generates integration problems in the BL model	58%	42%	
11—The different organizations collaborate without conflicts	74%	26%	
12—Differences in the formation and opinions of key actors affect the interaction in the BL model	50%	42%	8%
13—Knowledge that natural protected areas can be accepted or rejected	58%	16%	26%
14—The nomination of a protected area causes use restrictions	66%	34%	

3.4. Local Conflicts

There were six topics represented as codes related to conflicts. The four most frequent were: conflicts due to scale power, between stakeholders, natural protected area rejection, and negative effects resulting from a decree (Figure 2).

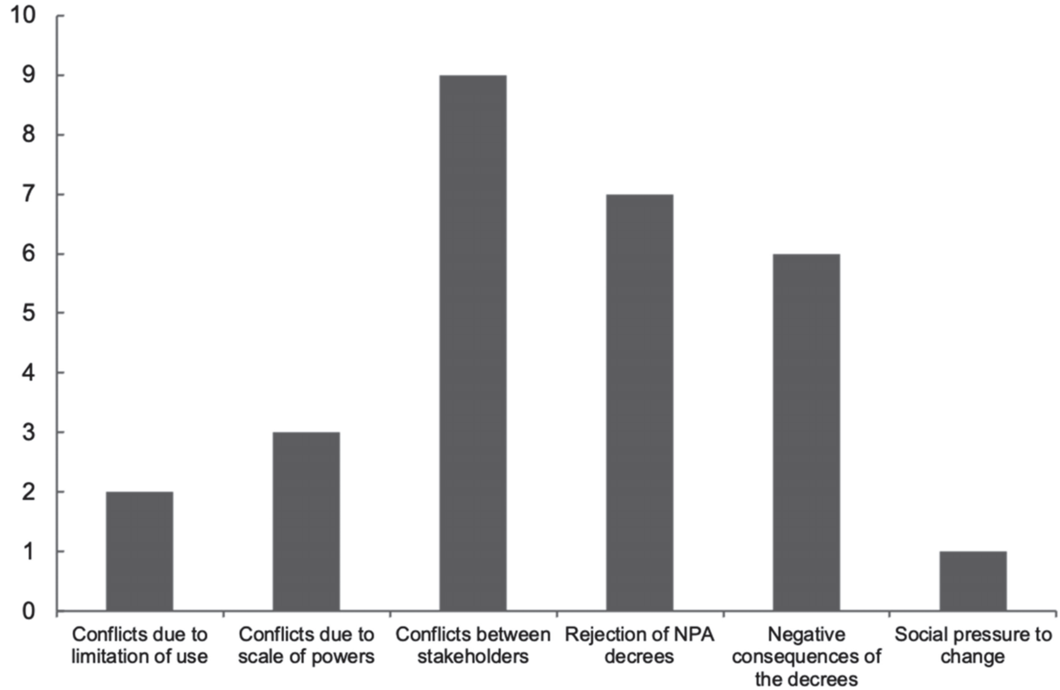

Figure 2. Frequency of responses by local conflict codes.

These conflicts are described next:

(a) Conflicts between actors. This includes conflicts between those who prefer to continue using natural resources "as per usual" and those who prefer or are interested in conservation. The former argue that resources are necessary for survival and that differences in thinking are normal, as is the case in any social issue. The latter believe that a change is necessary.

(b) Rejection of natural protected area decrees. There is little information on the subject, there are economic interests other than protection issues, the idea of what natural protected areas is wrong, and if natural resources are protected, local populations could be affected.

(c) Conflicts due to power scales. There are three negative consequences detected: people are reluctant to change their way of thinking, they do not see benefits from conservation, and there are problems of land ownership

(d) Negative consequences due to protection decrees. This group did not consider that there were transcendental conflicts, it was only mentioned that they could arise due to economic and knowledge differences, as well as the power and influence of large companies in the region.

3.5. Conservation and Knowledge in Protected Areas

The responses about Conservation and knowledge were distributed in 11 groups (Figure 3).

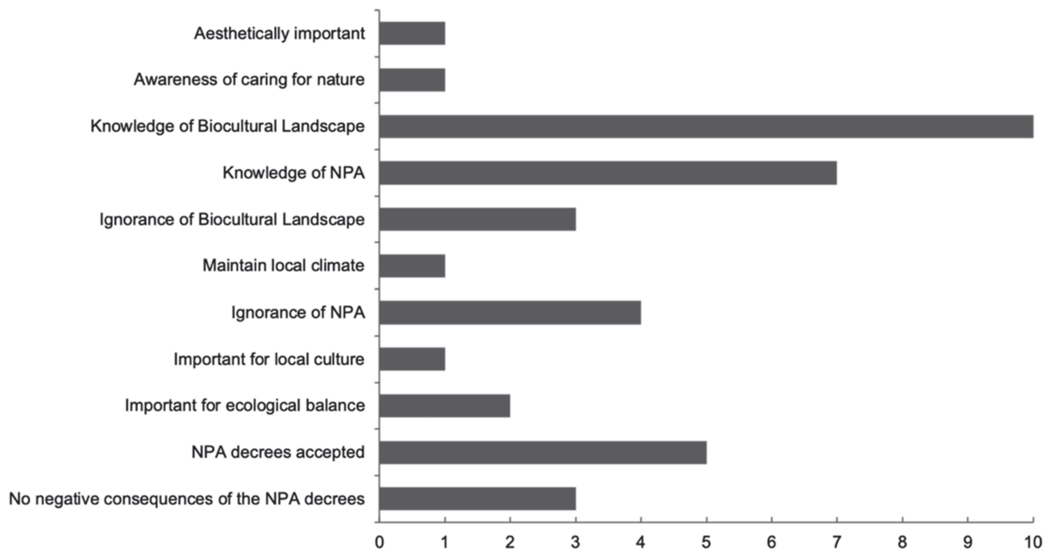

Figure 3. Frequency of responses by conservation and knowledge codes in protected areas (NPA).

The six most relevant codes in this group were selected for this theme and are next described:

(a) Knowledge of the concept of BL: The opinions state that the term is well known in the four municipalities involved, where those who know best about it are the producers.
(b) Knowledge of protected natural areas: It is perceived that there is this knowledge through the local working groups developed by the BL staff; however, it is not enough because they do not know the function of these areas or they only have partial ideas.
(c) Acceptance of the protection decrees: It is accepted since responsible use is encouraged, awareness has been raised and agreements created, and, also, more people have accepted it since they have observed that those who agree have obtained benefits.
(d) Lack of knowledge about natural protected areas: They mention that they have only heard about the topic without going deeper into it.
(e) There are no negative consequences: They consider that it is favorable for the environment since conservation is positive and local participation has been more active.
(f) Ignorance of the BL: This is because erroneous information has been distributed.

In general, the interviewees consider that those people who accept the decrees are aware of their benefits since they have encouraged a respectful use of nature, agreements have been reached and a collective conscience has been generated. Although most people in the study area know about the natural protected areas, misinformation is a determining factor, as they have misconceptions or partial ideas, and are unaware of their function and objective. For those who know about the BL area, it is due to their participation in the project (mainly producers, merchants, and local leaders).

3.6. Territorial Management

The nine most popular codes of a total of 16 (Figure 4) in the territorial management group, which proved to be the most extensive, were selected and are described below.

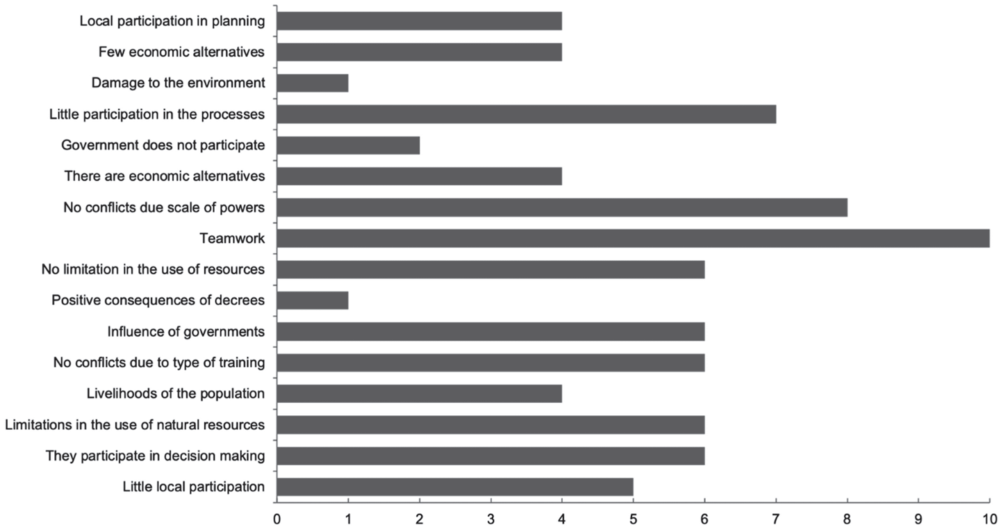

Figure 4. Frequency of responses by territorial management codes.

(a) Teamwork: The participants in the BL model are willing to do so, so it is possible to work without conflict.
(b) There are no conflicts over power scales: These are people with a group conscience in which specialists are integrated and contribute their knowledge so that there is equal participation without distinction.
(c) Participation in the planning processes: It has been achieved, but it depends on the subject, since not all of them can be agreed upon, in addition, sometimes only the participation of trained personnel is possible.
(d) Influence of governments: It exists positively since we have worked with different secretariats, directorates, and agencies, in addition to the existence of programs and projects that are added.
(e) There are no conflicts due to types of training: All people, from their area of knowledge, contribute their ideas, so there is respect, group awareness, and equitable participation, which has also been possible thanks to the participation of specialists.
(f) Limitation in the use of natural resources: Norms have been established for the use of resources, as well as ejido programs, which has made it possible to regulate some activities.

The interviewees commented that although there is a certain amount of rivalry in terms of power and the type of training of those involved in conservation issues, they have managed to control the situation because most of the activities are voluntary, where participation is diverse and everyone contributes their knowledge, different disciplines are integrated, and there is teamwork, both with the localities and the organizations. Limitations on the use of natural resources are due to norms and agreements that allow for their regulation. Regarding planning issues and local participation, it depends on the aspect being discussed, since some points are very specialized and it is difficult to reach a consensus on the decision, so only experts in the field participate. The communities depend on local resources, so they need to know the decrees, because of the need for them for their economic development and social dynamics, and this is an aspect that has been strengthened, as they have been able to learn more about the measures and regulations related to the project, all of which has awakened environmental awareness in the region.

4. Discussion and Conclusions

Local communities are gradually becoming more involved in the BL area's planning processes, although rural populations usually have limited knowledge about the objectives of a natural protected area and its functioning; they perceive its importance but do not identify direct benefits [44]. Latin American protected areas have reported that many of the erroneous ideas about them are frequently assumed as real, creating conflicts and affecting the collaborative work [11]. This causes a different perception of the BL model affecting local participation and can complicate the acceptance of participatory conservation models. In this sense, it is necessary to perform effective interventions to improve the planning and communicating process. This would pose a challenge, since, more than a benefit, people may consider it a threat that natural areas, even cultural ones, may be protected, since their social dynamics are developed based on these, commercially, economically and traditionally.

In addition to the misconception of the model, conflicts arise due to the diversity of interests that certain local stakeholders have, so progress could be slow or simply non-existent. In theory, everyone can participate in the BL model, but in specific cases only the members of relevant groups can participate since specialized intervention is required, a fact that could be interpreted as a simulation [21]. As Carvalho proposes [45], to be successful in the conservation and management of protected areas, it is necessary to ensure that people participate actively, not simply integrating their knowledge and expertise when it is opportune.

A virtuous cycle is developing in the BL model, the formal and informal agreements to protect the biocultural landscape have incentivized local participation, enhancing the information and management of the area as observed by other authors [14,15].

The main challenge of the BL model continues to be social participation, although it has been improved, if vertical implementation of their strategies does not effectively consider community participation [28].

Something that is undeniable is that people have acquired greater environmental awareness, since those who actively participate see the protection decrees as a positive measure, because they do not find a limitation in the use of nature, which evidently reflects an important advance in conservation. This differs from what usually happens with traditional natural protected areas [11].

The BL model has made clear progress by monitoring its activities, knowing the flora and fauna of the region and the commercial activities with greatest potential. However, there are aspects that need to be worked in greater depth: clarifying what the natural areas consist of, clarifying what their rules and regulations are, and communicating adequately will all allow local people to become more involved in conservation issues. Increasing participation can also contribute to a greater dissemination of knowledge that would reinforce environmental awareness.

Adaptive governance leads to flexible collaborations, which focus on learning and decision-making processes that involve multilevel actors, with the objective of negotiating and coordinating issues such as landscape and seascape management [15]. When actors with different interests coexist, adaptive governance enables understanding and improving governance responses to challenges faced in sustainability issues, including learning and collaboration with sectors and scales that have a shared vision through monitoring and information exchanges, networking, and conflict resolution.

Related to the questions that guided the research, we can answer that stakeholders' interaction and collaboration evidence that the BL model surpasses the traditional model of protected natural areas implemented by governments, but there are still challenges related to local participation. Although to some extent the BL model repeats the linear and hierarchical approach for conservation, since it was designed at the beginning by governments of different scales together with non-governmental organizations, and it was not prompted by community, it was not imposed. It has acquired solidity through collaborative work as a form of participation of different key actors that guide the actions.

We can also answer that BL area functions in an innovative governance context where the social participation and collaboration are distinctive, but it has been a slow process.

Addressing issues in the interest of all stakeholders, as proposed by Zhang [46], can help in avoiding conflicts and in improving the local development and the livelihood of communities. The theory said years ago that conservation should be reached if participative forms of conservation were performed; we underline that conservation must be done based upon biocultural approaches in a real participative exercise.

As to whether the model has achieved the BL conservation objectives in this area, it is too soon to see results on particular species, ecosystems, or social groups, but, as stated at the beginning, social participation is required for conservation [9], so it is on its way. Future research should study these particular indicators to evidence positive field changes in biocultural conservation.

Finally, one of the limitations of this research that we recognize is that the World Bank/WWF Management Effectiveness Tracking Tool [41] adapted here to evaluate the BL area in Jalisco was intended to facilitate reporting on progress in management effectiveness from the BL staff perspective. The stakeholders included in the study were pro-BL due the tool used [42], so in the process we may not have considered key stakeholders who did not agree with the model or who are affected by the achievement of its objectives as proposed by Benn et al. [43]. To avoid bias, it should not be the only analysis conducted for adaptive management purposes

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Article

Visual Impact Assessment in Rural Areas: The Role of Vegetation Screening in the Sustainable Integration of Isolated Buildings

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Abstract: Rural tourism has led to an increase in the number of buildings, meaning that visual integration of these buildings into the landscape is not always achieved. The silhouettes of buildings in rural areas are always recognisably simple but can be visually discordant if their sharpness is high. The literature provides analyses of how the visual impact of a given construction can be minimised by vegetation screening. The main objective of this study was to propose a method of quantifying the visual impact of isolated buildings (1 (low visual impact)–5 (high visual impact)). The method combines a measurement of the sharpness of building silhouette lines and vegetation screening (*Scr*) percentage (high or low) using theories based on the cognitive aspects of visual perception and digital image processing. The method was validated through a survey in which photos were shown to a wide range of respondents. A second objective was to analyse the combined effect on the visual perception of *Scr* and building colour (C), which is broadly analysed in the literature. The main result is that the required percentage of vegetation screening for a building with sharp lines and discordant colours to be accepted was determined to be around 40%. The proposed method can be applied by landscape planners; it is easy to use, and the cognitive principles on which it is based do not depend on the working environment.

Keywords: vegetation screening; building silhouette lines; visual impact assessment; sustainable rural development; planning policies

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1. Introduction

The European Union approved the Environmental Impact Assessment (EIA) directive in 1985. Since the introduction of this directive, the landscape was considered an important factor for analysis in any environmental assessment [1]. In 2014, modifications to this directive included the need to address the visual impact of projects. Since then, in EIA studies, reduced visual impacts of constructions have been increasingly considered to better preserve the historical and cultural heritage of the landscape.

The integration of human activities in a landscape constitutes a major challenge for the agents that work in and interact with the natural environment. Mitigation of visual impacts in these environments requires the application of various methodologies and modes of action that are being proposed in the scientific field, for example, those in [2–9]. In this context, the use of vegetation screens as a filtration medium constitutes an effective tool to reduce the visual impact of buildings and structures in rural areas.

1.1. Building Silhouette Lines

Lines can be defined as real or imaginary paths that guide the line of vision of an observer when abrupt differences in form, colour, or texture are perceived. Any line has three characteristics that can be studied and measured [10]: sharpness, complexity, and direction.

Sharpness refers to the level of line definition. Intensity and continuity define sharpness and can be measured using two parameters: length and saturation [11,12].

a. Length: The greater the length, the sharper the line. In this sense, the lengths of the lines of a building in a natural setting offer no relevant information from a visual standpoint. That is, the straight lines of a building are always sufficiently appreciable compared with a natural background due to their simplicity.
b. Saturation: The more saturated the colour that defines a line, the sharper it will be. Saturation can be calculated by measuring the saturation of the colour that forms a line. If this is not possible, in instances where, for example, a line is formed by contact between two surfaces, then the saturation can be calculated by the difference between the saturations of the two colours that define it or by the difference in their standard deviations. Colour contrast on the border lines accentuates the boundaries more than the line itself [13,14].

Complexity refers to simplicity, direction changes, kinks, breaks, or undulations in a line. Simple and continuous lines are more visually dominant than discontinuous and broken lines [10,15]. Natural landscape lines are usually more complex than building lines. Therefore, building lines are normally in contrast with countryside landscapes. For this reason, contrast analysis of line complexity in rural areas is not performed in this study, as it has been reported before [11].

Direction is the position of the line in relation to the horizontal dimension. It can be studied by measuring the line angle against the horizontal plane. In visual perception, the vertical dimension is dominant over all other directions [10,15]. This parameter is not considered in the present study, as horizontal building lines are dominant in rural environments, with the exception of buildings that exceed the skyline [16], which are not addressed here.

In summary, the visual perception of a building depends on the nature of the boundary between the building and its background. A key determinant is the sharpness of this boundary [13,14,17,18].

1.2. Building Colour

Lines that define the forms of objects are the first elements that our brains attempt to locate [17] before focusing on other visual properties associated with colour and texture.

In relation to buildings, the construction design variable that has the most significant visual effect on perception appears to be colour, as has been demonstrated in earlier studies [19].

Colour is defined by its *hue* (H), *saturation* (S), and *brightness* (B). Pronounced differences in mean values of H–S–B between building surfaces and a background generate visual impacts [20]. *Internal contrast* is provided by the standard deviations of each of the basic colours of a surface. With high deviations, colours become more intense and artificial [3]. Therefore, the *internal contrast* of colours of a building (walls and roof) against the background intensify the possible *H–S–B* impacts [14].

Although the effect of colour in conjunction with the lines and forms of a building has been studied [11], it has not been quantified in terms of aggregate impact. Notable differences between the colours of the surfaces of a building and the colours of the surroundings create visual impacts [20]. If the colour of a building is acceptable, it is possible that high sharpness of its silhouette lines, while making the building recognisable, will be tolerable. However, if the colour is not acceptable and it occurs in combination with a geometry of very sharp silhouette lines, the overall effect will be more visually discordant [11,19].

1.3. Partial Vegetation Screening of Buildings

Building types in rural contexts comply with their function (residential, tourism, agro-industrial, or farming), and it is not always easy to ensure that their geometry suits their surroundings. It is easier to work with other changeable elements, such as colours and materials, the positive effects of which on integration have been demonstrated [12,19], or to consider visually improving the lines of the building by partial vegetation screening [21]. The authors of [21] showed that using vegetation around a building improves the visual appearance of a built area by 9–17%.

Visual absorption capacity is defined as a landscape's ability to absorb physical changes without transformation of its visual character or quality [22]. In this context, partial screening of an impact that requires mitigation can contribute to improving the visual absorption capacity of a landscape. This concept is not new and has appeared in numerous studies demonstrating the benefits of its use in integrating scenes with various levels of intervention [23–26]. Recent studies have shown that the impact of human constructions (e.g., motorways) can be reduced, improving the effect of visual absorption, with trees placed between the construction and the point of observation [27].

1.4. Previous Impact Measurement Associated with the Present Study

García et al. [11] proposed an initial method for visual impact measurement that combines an analysis of the sharpness of building lines and vegetation screening. The conclusions of their study were promising, as they demonstrated that vegetation screening of buildings with sharp lines (relative to the background scenery) has a positive effect on perception. In the study, the authors analysed various percentages of building screening, but the screening ranges (0–20%, 20–60%, 60–80%, and >80%) were not determined using any scientific criteria other than a gradual increment of the amount of screening in four intervals of equal size. Moreover, the authors did not provide precise data about the percentage of screening in each modified image, which would have enabled more accurate discussion of the comparison of the results obtained between cases. Despite this, it was shown that at some stage in the 20–60% interval of screening a building with sharp lines, the probability of obtaining improved ratings increased. This interval is very large if we wish to establish a critical point of change. Therefore, although the study demonstrated that a building is rated higher as the level of screening increases, the authors did not determine the minimum percentage of vegetation necessary for visually efficient minimal inversion.

The Weber–Fechner (W-F) law of stimulus [28] demonstrates that the relation between increased stimulus and the perception of the stimulus is logarithmic [29]. In this way, the perception of increased stimulus is appreciable only when the increases occur at constant ratios of change relative to the original stimulus: "If a stimulus varies as a geometric progression, the corresponding perception is altered in an arithmetic progression" [28].

Recent studies have taken a further step by attempting to determine the amount of screening necessary for sufficient integration as a percentage of the total built area [30]. One of the conclusions of Garrido et al. [30] was that using vegetation with an intermediate degree of filtering in the frontal plane of a building (40–50%) increases the possibility of the perception of the façade improving from poor or very poor to at least acceptable. However, they did not determine a possible logarithmic relationship between increases in the percentage of vegetation concealment of buildings and their visual acceptability.

1.5. Aims of the Study

The overall aim of this study was to provide planners, architects, and engineers with quantifiable design variables based on the use of vegetation as a design element in rural contexts.

The specific objectives were:

(1) To propose and validate a method of assessing the visual impact of isolated buildings in rural contexts, combining measurements of silhouette line sharpness and reduction in sharpness using vegetation screening;

(2) To determine the aggregate effect of screening the lines and colours of a building on the overall visual impact of the built area;
(3) When the colour of a building is not appropriate:
 - To determine the mathematical relationship that exists between the percentage of vegetation concealment of a building and the assessment of its integration by an average observer; and
 - To determine a minimum percentage of vegetation screening with which visual integration of a built area can be achieved.

The novelty of this study lies in its approach and in the methods followed in its implementation, as will be detailed later. In essence, the use of an aggregate system for the sum of visual impacts and the use of a psychological approach [28] to establish the appropriate levels of filtration by vegetation make our present findings innovative.

A pilot area and initial buildings were chosen for the design and development of assessment surveys to validate the method, as explained in Section 2.

2. Materials and Methods

2.1. Proposal for Assessing Screening Impact (ScrI)

2.1.1. Description of the Method

Bearing in mind the studies mentioned in the Introduction, a proposal for measuring visual impact based on the initial study by García et al. [11] is shown in Table 1. In this case, we used 40% increments in vegetation screening, according to the results of Garrido et al. [30]. Two screening classes were established: 0–40% and 40–80%.

Table 1. Proposed assessment of screening impact (*Scr*I). Qualitative classification of impact: DWC—diversity without contrast; CC—compatible contrast; PCC—poorly compatible contrast. Adapted from [11].

	***Scr*eening: 40–80%**		***Scr*eening: 0 ≤ 40%**	
Sharpness Lines	**Impact**	**Rating**	**Impact**	**Rating**
Insinuated	DWC-CC	1	CC-PCC moderate	3
Intermediate	DWC-CC	1	CC-PCC high	4
Sharp	CC	2	CC-PCC very high	5

"Mystery" is defined as the promise of new information if one could travel deeper into an environment, which has been studied by several authors [24,31–33]. Although this definition is subjective, it is directly related to the degree to which a scene is concealed or filtered by natural elements, such as vegetation [34]. Because mystery denotes the promise of new information [24], scenes that are excessively concealed could decrease the attractiveness for an observer. Therefore, for this work, screening vegetation over 80% was considered to not permit visibility of constructions, and therefore, such levels of concealment were not analysed.

The proposed method involves measurement of the sharpness of silhouette lines (Table 1), as indicated below (Figure 1a).

The relation between vegetation and sharpness (Table 1) gives rise to the following image types: those classified as having little impact, i.e., from "diversity without contrasts" to "compatible contrasts" (DWC-CC); images with compatible impacts (CC); and images with greater impact, from "compatible contrasts" to "poorly compatible contrasts" (CC-PCC). This qualitative description of impact is derived from the initial method described by García et al. [11], which may be consulted for further information.

However, this classification is not very accurate in terms of assessment if the aim is to precisely determine the thresholds of change in the rating of a building and its surroundings.

This is particularly important at the CC-PCC threshold, where impacts are more easily recognizable to the human eye [35]. In the study by García et al. [11], not all the cases classified as CC-PCC were rated as initially expected. In their study, images with lower percentages of vegetation (0–30% measured on a photo) were rated differently depending on the sharpness of the lines of the building (greater or lesser). In the lowest screening class (0–40%), the present study therefore includes concepts of “very high”, “high”, and “moderate” CC-PCC impacts, according to sharpness, proposing a numerical ranking of impacts (1–5) based on both factors (Table 1).

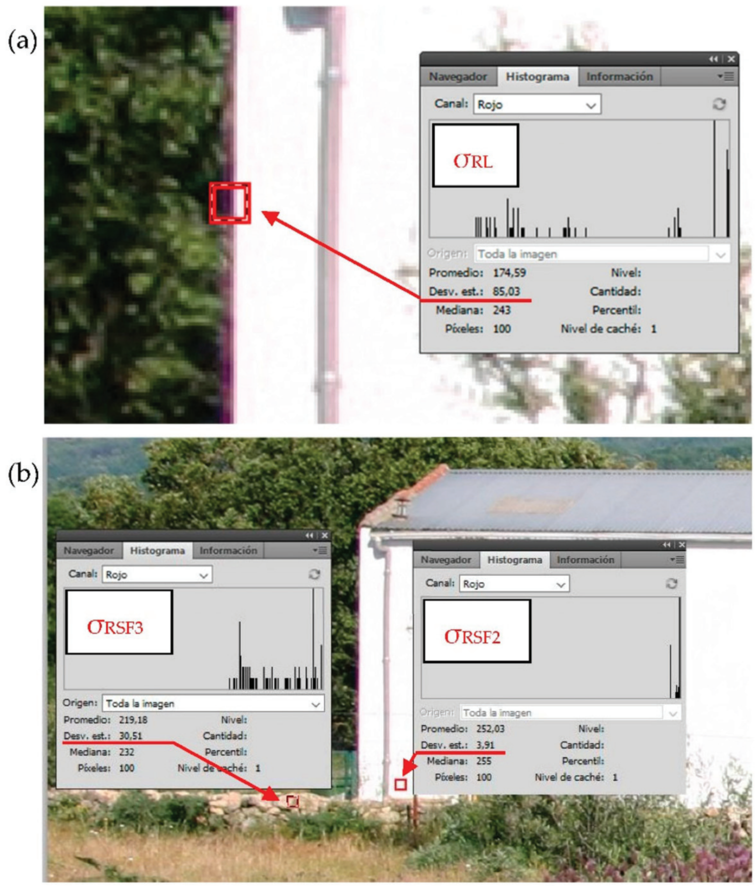

Figure 1. Colour histogram statistics. 1.(**a**) Example of a measurement window for the sharpness of building lines. The standard deviations (σ_x) of the three colour channels (x = R, G, B) in a measurement area that includes the line (L) under study: R (σ_{RL}), G (σ_{GL}), and B (σ_{BL}). The line is determined to be sharp if any σ_{xL} is greater than 40 (example of red channel SD measurement: σ_{RL} = 85.03). 1.(**b**) Example of measurement windows for internal contrast assessment of the building. For its calculation, σ_x comparisons of the three colour channels (x = R, G, B) are used between two independent measurement areas, not necessarily adjacent: one in the building (roof (SF1) or façade (SF2) and another in the environment (most dominant exterior element (SF3)). As many as six comparison pairs can occur between the building and the environment: three comparisons of roof–environment and three comparisons of façade–environment: σx_{SF1} vs. σx_{SF3} and σx_{SF2} vs. σx_{SF3}, where x = R, G, B (example of red channel SD comparison between façade and surrounding: $|\sigma_{RSF2} - \sigma_{RSF3}| = |3.91 - 30.51| = 26.6$). Adapted from [11,12,19].

2.1.2. Quantification of the Method

The application of this method is based on measuring the parameters on a photo using a digital image processing program (Photoshop CC). The photo resolutions used in this work are in the range of 100–150 dpi. These resolutions are appropriate for comparing the building with its surroundings and viewing construction details [11]. This range is also sufficient for a web-based survey that requires a minimum resolution of 76 dpi.

The screening percentage is obtained by dividing the number of pixels occupied by vegetation on the façade by the total number of pixels that make up the building façade.

The sharpness of a border line or silhouette line is calculated by the standard deviation of the mean of the colours in the basic colour channels (σ_{xi}; x = R, G, B) on the boundary between the surfaces of the building and the background [11] (Figure 1a). This is performed using quadrangular sample areas containing a border line that is located between the building and the background. The resolution of this capture window of 10×10 pixels is, in theory, sufficient for calculating the sharpness of lines in photo resolutions of 100–150 dpi; however, photos with higher resolutions require a proportional increment in the quadrangular capture window. The number of sample areas or windows can vary, but a minimum of three must be used.

The standard deviation (SD: σ) for the red (R) (0–255), green (G) (0–255), and blue (B) (0–255) channels (σ_{xi}; x = R, G, B; i = 1 − n) is calculated using Adobe Photoshop (C) for each sampling area, and the arithmetic mean per colour channel is calculated for the building (Equation (1)).

$$\overline{\sigma}_x = \frac{\sum_{i=1}^{n} \sigma_{xi}}{n} \quad (1)$$

where x = R, G, B, and i = number of sampling areas.

Depending on the means obtained, sharpness is classified as high (SD > 40) (for any of the three channels), medium (SD 26–40), or low (SD < 26) [11].

2.2. Additional Assessment of Colour Impact (CI)

The study is complemented by an analysis of the colour of the built area, using the method for colour impact measurement which was described previously [36].

This method considers both the visual characteristics of the colours (hue, saturation, and brightness) and the internal contrast between the building and the surroundings.

Colour impact was determined by comparing the mean *hue (H)*, *saturation (S)*, and *brightness (B)* of colours between the building and the most dominant feature in the surroundings. Single main colours were selected from the walls and roofs to represent the colour of the buildings. *H*, *S*, and *B* are compared using selected sampling areas (10×10 pixels) representing the roof (SF1) or the facade (SF2) of the building, and the feature chosen in the surroundings (SF3).

The average values of H (0–360°), S (0–100%), and B (0–100%) obtained for SF1 and SF2 were then compared to the mean values recorded for SF3 by the simple subtraction of mean values between building and surrounding. As many as six comparisons between pairs were performed—three from the facade vs. three from the roof.

Comparison pairs showing high contrast were considered based on the assumption that (1) the larger the number of high-contrast *HSB* pairs, the greater the visual impact should be and (2) the larger the number of impact pairs attributable to the facade, the more visible the building should prove to be. Differences in hue (H) exceeding 72° were interpreted as generating high contrast (poorly compatible contrast (PCC)), and this threshold was set at 30% for differences in *saturation (S)* or *brightness (B)* [19]. When differences were between 36° and 72° in *H* comparisons and between 15% and 30% in S or B comparisons, there were no colour impacts (compatible contrasts (CC)). Lastly, diversity without contrast (DWC) occurs when differences fall into the range of 9–36° for H pair comparisons and into the range of 5–15% for S or B pair comparisons.

According to these earlier studies, colour impact is determined by comparing the means of *hue (H)*, *saturation (S)*, and *brightness (B)* of the colours of the building and the predominant surface or element in the surroundings, including the standard deviations of the internal contrast of the building relative to the background (Table 2). Using Photoshop, it is possible to establish comparison pairs by colour channel between building surfaces (roof and façade) and the majority surface in the surroundings to classify the overall colour impact of a building. When an impact pair was established, the method was completed by measuring the internal contrast. In cases with no impact pairs, this parameter was not measured. Internal contrast was measured by comparing the standard deviation obtained for colour channels (R, G, B) within the same sampling areas used for HSB comparisons (10 × 10 pixels). Internal contrast was deemed low (↓) when differences were <5 points, medium (≈) for differences in the range of 5–15 points, and high (↑) for differences >15 points [12] (Figure 1b).

Table 2. Assessment of colour impact (CI).

Colour Impact (CI)	Comparison between Building Façade and Surroundings		Comparison between Building Roof and Surroundings		Total *H*/*S*/*B* Pairs with Poorly Compatible Contrast (PCC)
	Number of *H*/*S*/*B* Pairs with Poorly Compatible Contrast (PCC)	Internal Contrast (+)	Number of H/S/B Pairs with Poorly Compatible Contrast (PCC)	Internal Contrast (+)	
(1–2) *	0	NM	0	NM	0
2	0	NM	1	↓	1
3	0	NM	1	↑≈	1
3	1	≈↓	0	NM	1
3	0	NM	2	↓	2
3	1	↓	1	↑≈↓	2
3	1	↓	2	≈↓	3
4	1	↑	0	NM	1
4	1	↑≈	1	↑≈↓	2
4	0	NM	2	↑≈	2
4	2	≈↓	0	NM	2
4	1	↑≈↓	2	↑	3
4	1	↑≈	2	≈↓	3
4	2	↓	1	↑≈↓	3
5	2	↑	0	NM	2
5	2	↑≈	1	↑≈↓	3
5	0	NM	3	↑≈↓	3
5	3	↑≈↓	0	NM	3
5	Up to 3	↑≈↓	Up to 3	↑≈↓	>3

Notes: NM—not measurable; ↑—high; ≈—medium; ↓—low. (1–2) *—comparisons between building and surroundings reach compatible contrasts (CC) or (2) diversity without contrast (DWC) (1) at most. (+)—Internal contrast is measured as the standard deviation of the central colour value (mean) and the values on the rest of the surface in the basic channels of red (R), green (G), and blue (B). Data from [36].

Finally, the impact was converted into a simple scale of increasing ordinal impacts from 1 to 5 (Table 2). Further details about this method of measurement are provided in studies by Montero et al. [36] and García et al. [19].

2.3. Assessment of Aggregate Impact (AI)

In formal impact assessment methods, the simple aggregate sum of partial impacts has been demonstrated to be a suitable indicator for assessing global visual impacts [25,26].

In the present study, the method proposed for assessing the aggregate impact resulting from the screening and colour variables is the simple sum of the values of *Scr*I and CI, as calculated in Tables 1 and 2.

2.4. Validation of the Study

To validate the proposed method for measuring screening impact, various images were created in Photoshop and used in a survey administered to a wide range of respondents. Real photos of isolated buildings in periurban locations were selected in a study area representative of the central–western region of Spain in terms of landscape, relief, and architecture.

2.4.1. Study Area and Photo Capture

The Ambroz Valley (inland Spain: [40°15′0.4″8 W-6°01′10″8 N]) was chosen as the study area because tourism has increased in the area despite a drop in the population, among other reasons [37] (Figure 2). An inventory of new constructions was conducted by field work and using geographical information systems (GIS). Buildings that were difficult to access or were poorly visible from main roads were not included. Eight initial buildings were chosen for separate or combined analysis of the study variables: scale, colour, materials, lines, and forms. Two of these eight buildings (Figures 2 and 3) were chosen for the study objectives. The selection criteria were: (1) use or type of building: agricultural or residential (the two predominant uses in the chosen area [37]); (2) location: isolated buildings in periurban areas on the side or in the bottom of valleys with a mountainous background (allowing contrast analysis); and (3) optimum visibility for photo capture.

The following guidelines applied to photo capture: (1) sufficient distance from the observer to the building so that the photos show as many details of the building as possible and part of the landscape background. In previous studies, this meant that the building occupied 25–30% of the total area of the image [38,39]. (2) Avoid taking photos in adverse weather conditions, such as rain, cloud cover, fog, or mid-day sun [40,41].

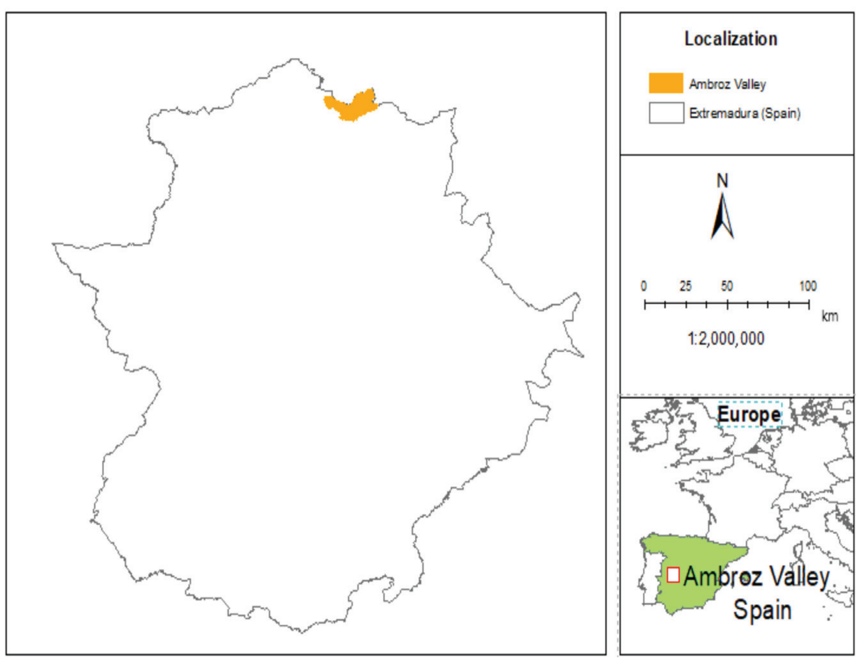

Figure 2. Map of location of Ambroz Valley.

Figure 3. Survey images used with group 1 participants (residential buildings). Variable screening (*Scr*) shows two levels of change in the percentage of vegetation in front of the building (0–40% or 40–80%). The variable colour (C) presents two study proposals: (+) positive impact of building colour of less than 3 points; (−) negative impact of building colour of more than 3 points.

2.4.2. Generating Survey Images

Using the two real cases chosen for the study, six survey images were proposed for each building type (residential or agricultural: cases A, B, C, D, E, and F). The images were obtained by modifying the real case using Photoshop, resulting in 12 test images for analysis: 6 residential and 6 agricultural (Figures 3 and 4).

From each sequence of six images, four cases corresponded to variations in the vegetation element (Figures 3 and 4, cases A–D), maintaining the original design of the initial photo and thus isolating the effect of vegetation from other variables in the statistical analysis. Adding a further element to the work completed in 2010, case C presents a configuration of aligned vegetation, included with the aim of confirming whether the arrangement of vegetation has a significant visual effect with regard to irregular configurations B and D.

The other two images (Figures 3 and 4, cases E and F) are combinations of two levels of screening, with a change in the original colour, with the purpose of analysing the possible combined effect of colour and screening. Using the 12 cases and based on Tables 1 and 2, the impacts (CI and *Scr*I) and their aggregate sum (AI) were calculated before the survey was administered (Figures 3 and 4).

From the remaining six initial cases, other survey images were created (32 in total) to assess the analysis of change in other variables not included in this study [36,42]. This resulted in a total of 44 (32 + 12) images to be used for the public survey.

Test images OS A, B, C, and D: analysis of screening maintaining constant colour. Ordered from highest to lowest AI.			
A (Real case)	**B**	**C**	**D**
			
*Scr*₁ (0–40%+ high sharpness) +C₁(−)	*Scr*₁ (0–40% + high sharpness) +C₁(−)	*Scr*₂ (40–80%+ high sharpness) +C₁(−)	*Scr*₂ (40–80%+ high sharpness) +C₁(−)
*Scr*I = 5; CI = 5	*Scr*I = 5; CI = 5	(Aligned) *Scr*I = 2; CI = 5	*Scr*I = 2; CI = 5
% veg. measured in foreground = 0%	% veg. measured in foreground = 29.1%	% veg. measured in foreground = 71.3%	% veg. measured in foreground = 72.2%
AI = 5 + 5 = **10**	**AI** = 5 + 5 = **10**	**AI** = 2 + 5 = **7**	**AI** = 2 + 5 = **7**
Test images A, D, E, and F: analysis of combined effect of *Scr* + C. Ordered from highest to lowest AI.			
A (Real case)	**D**	**E**	**F**
			
*Scr*₁ (0–40%+ high sharpness) +C₁(−)	*Scr*₂ (40–80%+ high sharpness) +C₁(−)	*Scr*₁ (0–40%+ high sharpness) +C₂(+)	*Scr*₂ (40–80%+ high sharpness) +C₂(+)
*Scr*I = 5; CI = 5	*Scr*I = 2; CI = 5	*Scr*I = 5; CI = 2	*Scr*I = 2; CI = 2
% veg. measured in foreground = 0%	% veg. measured in foreground = 72.2%	% veg. measured in foreground = 0%	% veg. measured in foreground = 72.2%
AI = 5 + 5 = **10**	**AI** = 2 + 5 = **7**	**AI** = 5 + 2 = **7**	**AI** = 2 + 2 = **4**

Figure 4. Survey images used with group 2 participants (agricultural buildings). The variable screening (*Scr*) presents two levels of change in the percentage of vegetation in front of the building (0–40% or 40–80%). The variable colour (C) presents two study proposals: (+) positive impact of building colour of less than 3 points; (−) negative impact of building colour of more than 3 points.

2.4.3. Participants and Data Collection

Two separate groups of respondents took part, and two samples of 22 (16 + 6) photos each were shown per group: residential type for group 1 (Figure 3) and agricultural type for group 2 (Figure 4). This design reduced the total number of photos per respondent to a more manageable number [11] and allowed the use of independent samples to assess the influence of each test image [36]. Test images were shown to each group randomly so that the answers were not affected by the order of appearance of the images [38,43,44].

Each respondent answered two questions for each image viewed: (1) "On a scale from 1 (Very bad) to 5 (Very good), how would you rate the integration of the building into the scene?" The rating scale, with increasing ordinal numbers from 1 to 5, allowed for ongoing processing of the answers; therefore, the average rating of each image was calculated [45]. These types of rating scales are considered reliable in studies of a social nature as a simple and efficient way of measuring participants' hedonic tone when given a visual stimulus [46]. (2) "From the following list, what would you change to improve the integration of the building into the environment? Scale of the building, Colours of the building, Construction materials, Vegetation around the building, Nothing". Respondents could choose only one of five possible answers for question 2. The accumulated response frequencies were calculated for each image.

A total of 1046 respondents answered one of the two designed surveys. Respondents were recruited through a specially designed website. The use of web pages for this type of study—of a social nature—has been shown to be efficient for collecting answers [47]. Group 1 (residential survey) comprised 559 participants, and group 2 (agricultural survey) comprised 487 participants. Participants were sorted by age, place of residence, and gender (Table 3).

Table 3. Study variables.

Variables	Categories of variables
AGE (A)	1 (≤15–25 years)
	2 (>25–55 years)
	3 (>55 years)
Place of residence (P)	1 (≤1000–10,000 inhab.)
	2 (≥10,000–500,000 inhab.)
	3 (≥500,000 inhab.)
GENDER (G)	1 (Male)
	2 (Female)
TEST IMAGE (I) Within subject	A
	B
	C
	D
	E
	F

2.4.4. Statistical Analysis of Results and Initial Hypotheses

The dependent study variables are the answers to the two questions asked. For question 1, the averages of the ratings per test image were used (rating average, RA), and for question 2, the accumulated frequency of the element of change most often chosen in each test image (% of element of change—EC) was used. The study factors or independent variables are shown in Table 3.

An initial analysis was conducted to determine whether the variables—gender (G), age (A), place of residence (P), and test image type (I)—affected the rating average (RA) (question 1). To this end, the following repeated-measures ANOVA test was designed: 3(A) × 3(P) × 2(G) × 6(S). The final variable (I) was a within-subject statistical analysis variable, whereas the other three (A, P, and G) were between-subject analysis variables. The statistical weight of the social variables is limited or null in the overall rating of each test image; therefore, they were not included in the main study.

Two repeated-measures ANOVA tests were performed for each building type, excluding the social variables. The independent variable was the test image type (I). The first test was intended to detect the isolated effect of screening (variable *Scr*, cases A–D) on the RA, whereas the second was performed to analyse the combined effects of the screening and the colour of the building on the rating (variable *Scr*: cases E, F, A, and B: residential (Figure 3); cases A, D, E, and F: agricultural (Figure 4)).

Significant ANOVAs were completed with post hoc analysis (Bonferroni test). Using this type of analysis, we can identify where the statistical differences were between the categories in the variable test image (I) that had significance for the answer.

Cohen's d was used to analyse the effect size of the significant differences observed. Following methods available in the literature [48], Cohen's d values of more than 0.8 were considered large effect sizes. The sample size in the final survey (n = 1047) was considered sufficient to detect at least medium effect sizes (Cohen's d of more than 0.5) at significant thresholds of statistical power ((0.90 = 1 − beta; beta = 0.10); alpha = 0.01) [49].

The results of the answers to the second question were analysed using frequency diagrams and the chi-squared test for both samples surveyed.

To determine the minimum percentage of vegetation for an image with a discordant colour to receive a good rating, a logarithmic regression analysis was performed on initial cases A–D of the agricultural sample, following the cognitive theories of the W-F Law.

The statistical research hypotheses were as follows:

- According to the proposed method, within a single class of vegetation screening, the same trend would be expected in the ratings, regardless of whether the trees were in a disperse arrangement or aligned and regardless of whether the percentage of vegetation was close to the upper or lower limit of the class. To determine this, cases B, C, and D in the residential group in the same screening class (40–80%) had different percentages of vegetation (51–72%) and two screening arrangements: disperse (cases B and D) and aligned (case C). Similarly, in the agricultural sample and in class 0–40%, two proposals were presented with different percentages, A (0%) and B (30%), to determine the performance of the chosen range. The effect of the vegetation arrangement (aligned or disperse) in cases C and D of the agricultural sample (both with screening values around 70%) also helped to test the independence hypothesis in the results regarding the tree arrangement.
- According to the proposed aggregate impact method, it was expected that the sum of the two impacts would cause a decrease in the rating as the sum increased. To test this hypothesis, test images A, B, E, and F (residential) and A, D, E, and F (agricultural) were used.

3. Results

In the present study, we classified effect sizes with a Cohen's d of 0.2 as small, those with values greater than 0.5 as medium, and those with values greater than 0.8 as high [48].

A preliminary global analysis of both samples showed that the group of respondents aged older than 55 years gave a better rating, on average, for all images than the youngest group of respondents (<25 years) and those in the middle age range (25–55 years) (data not shown); these results are similar to those obtained by Montero et al. [36]. However, the effect sizes of these results were not very high compared with the variable test image (residential: F (1552) = 7.693; $p = 5 \times 10^{-4}$; d = 0.33; agrarian: F (1481) = 16.010; $p = 1.8 \times 10^{-7}$; d = 0.52; alpha = 0.01.)

The analysis of respondents' place of residence in relation to the agricultural sample showed that respondents from places with fewer than 10,000 inhabitants gave slightly lower ratings than the remaining respondents (data not shown); however, the effect size was also low (F (1481) = 9.397; $p = 1 \times 10^{-4}$; d = 0.39; alpha = 0.01). In the residential sample, the answer trend was similar but not statistically significant. The effect of gender was not significant in the answers in either sample.

Only one interaction was significant: test image type (A-F) x age; however, again, the effect size was less than 0.5 in both samples (data not shown).

The variable test image (I, within-subject analysis variable) had more statistical weight in the rating average (RA) than the social variables (between-subject analysis variables).

For both population samples, variable I (A–F) was not only significant in the within-subject analysis but also had a large effect size (residential: F (1552) = 173.069; $p = 1.4 \times 10^{-34}$; d = 1.20; agricultural: F (1481) = 253.436; $p = 3.8 \times 10^{-46}$; d = 1.452; alpha = 0.01).

In summary, only the results of the within-subject analysis are presented, in view of their greater statistical weight.

3.1. Rating of Screening

The repeated-measures ANOVA was significant and had large effect sizes in both samples (Cohen's d = 0.741 in residential sample; Cohen's d = 1.09 in agricultural sample) (Figure 5). Therefore, depending on the variation in screening impact (*Scr*I), respondents' ratings varied significantly.

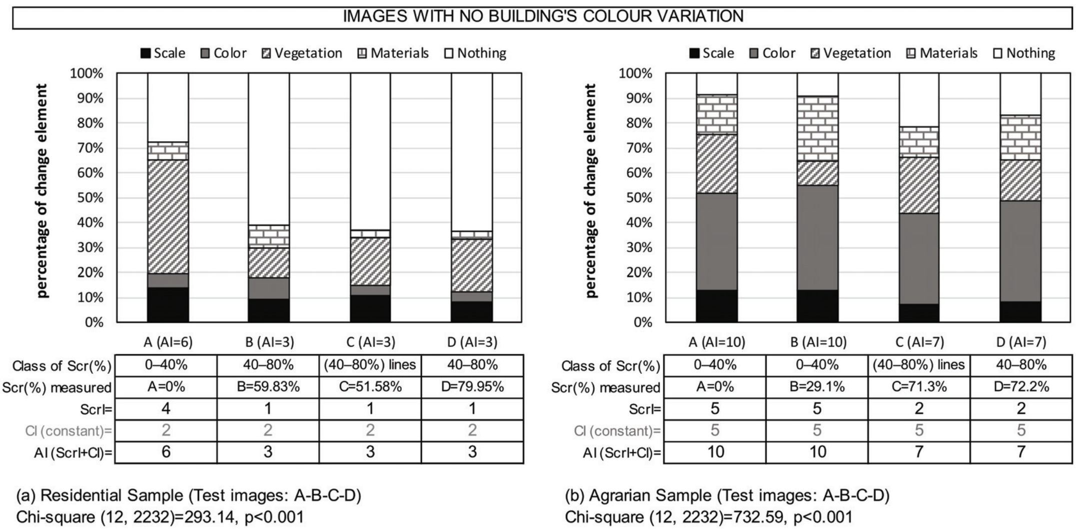

Figure 5. Results of repeated-measures ANOVA to quantify the isolated effect of screening on silhouette lines. (**a**) Rating average for Residential Sample (Test images: A-B-C-D, (Figure 3). (**b**) Rating average for Agrarian Sample (Test images: A-B-C-D, (Figure 4). Different letters in lower case indicate significant differences in RA between compared images (Bonferroni test).

For detailed analysis of where these significant differences occurred, post hoc analysis was performed to compare test images using the Bonferroni test in both samples (Figure 5).

For the residential sample, the differences occurred only between image A (*Scr* = 0%; *Scr*I = 4) and the other three test images. The initial hypothesis of equal answers between test images with the same class of screening was also confirmed, with no significant differences between images B, C, and D (*Scr* = 40–80%; *Scr*I = 1). The hypothesis was confirmed, regardless of whether tree arrangement was dispersed (B and D) or aligned (C) and regardless of whether the percentage of vegetation was close to the upper or the lower limit of the class (Figure 5a).

Similarly, for the agricultural sample, the initial hypotheses were confirmed. *Scr*eening class 0–40% showed no significant differences between test images A and B (*Scr* = 0–40%; *Scr*I = 5), regardless of the screening percentages. There were no significant differences between cases C and D in the 40–80% class, regardless of whether the trees were in an aligned or dispersed arrangement (*Scr* = 40–80%; *Scr*I = 2) (Figure 5b).

For the agricultural sample, wherein all cases present with a high CI, a logarithmic fit was sought for approximate determination of the minimum percentage of vegetation screening required for the test images to be rated as *RA* = 2.5 out of 5. In this regard, 2.5 was considered the statistical midpoint value of rating averages from on ordinal scale of 1–5 used in this work. This statistical value can be used as an adequate starting point for ensuring public approval of the visual integration of buildings.

The results of this fit were calculated using Equation (2). The fit had a high R^2, but parameters "a" and "b" were not significant (data not shown).

The *Scr*% that meets the assessment rating of 2.5 points on the increasing rating scale—as predicted with this model—occurs precisely at 40%.

$$RA = \text{a}\cdot\text{Ln}(Scr) + \text{b}\ \text{R}^2 = 89.4\%\ ;\ \text{a} = 0.426\ \text{b} = 0.992 \quad (2)$$

$$RA = Rating\ Average\ Scr = \%\ vegetation\ measured$$

3.2. Rating of the Combined Effect of Scr × C

Analyses of test image sequences A–D–E–F (agricultural sample) and E–F–A–B (residential sample) also showed the direct influence on image rating of the aggregate sum of the impacts of both study variables: colour (C) and screening (*Scr*). The repeated-measures ANOVA was significant, and the effect size was large in both samples (Cohen's d = 1.968 in residential sample; Cohen's d = 1.560 in agricultural sample) (Figure 6). Therefore, depending on the variation in the impact in both variables (*Scr*I + CI), respondents' ratings varied significantly. The Bonferroni test indicated the location of these differences between the test images in each sample, with a surprising similarity between samples (Figure 6). Overall and irrespective of the sample, the results show that the higher the sum of the impact resulting from both variables, the lower the rating will be (cases E (Figure 6a) and A (Figure 6b)) and vice versa (cases B (Figure 6a) and F (Figure 5b)). The cases of intermediate impact in both samples also had a similar response, with no significant differences between cases (Figure 6).

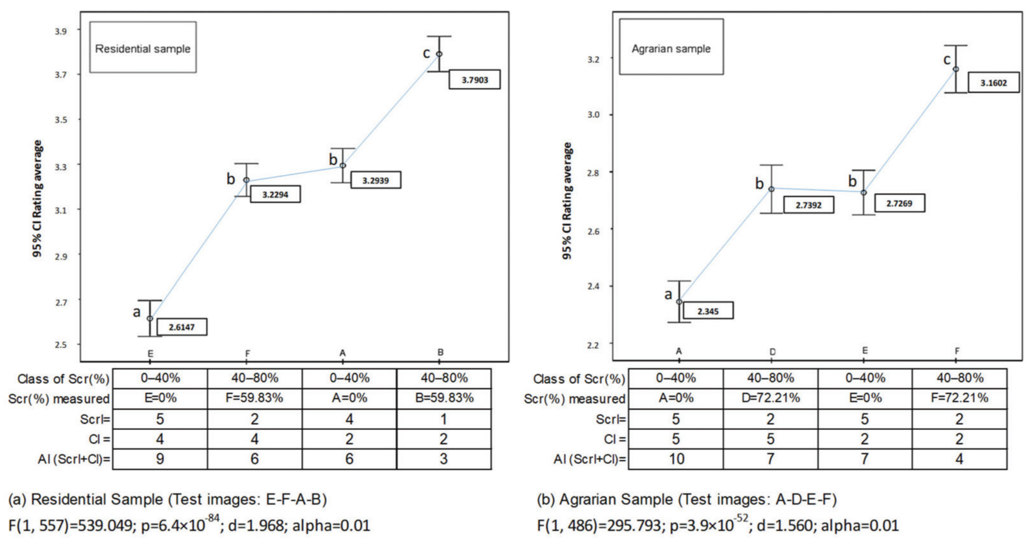

Figure 6. Results of repeated-measures ANOVA to quantify the combined effect of screening and building colour. (**a**) Rating average for Residential Sample (Test images: E-F-A-B, (Figure 4). (**b**) Rating average for Agrarian Sample (Test images: A-D-E-F, (Figure 4). Different letters in lower case indicate significant differences in RA between compared images (Bonferroni test).

For both samples, a decreasing and significant linear fit was obtained between the *RA* and the sum of the AI (Equations (3) (residential) and (4) (agricultural)). Once again, it was clear that the higher the increase in aggregate impact, the lower the average rating. Both fits had a high R^2. The fitting parameters "a" and "b" were also significant in both equations (data not shown).

$$RA = \text{a} - \text{b}\cdot(\text{AI})\ \text{R}^2 = 99.2\%\ ;\ \text{a} = 4.408\ \text{b} = 0.196 \quad (3)$$

$$RA = \text{a} - \text{b}\cdot(\text{AI})\ \text{R}^2 = 99.9\%\ ;\ \text{a} = 3.694\ \text{b} = 0.136 \quad (4)$$

$$RA = \text{Rating Average AI} = \text{Aggregate Impact}$$

3.3. Analysis of Frequencies: Elements of Change

The answers to the second question differed between samples when comparing test images A, B, C, and D (Figure 7a,b). In the residential sample, when the percentage of vegetation increased (cases B, C, and D), selections of the option to change "nothing" increased. Moreover, these images had the lowest AI (3) and were the highest-rated. However, in case A (AI = 6), with no vegetation in the foreground, the number of answers electing to change the "surrounding vegetation" increased. Colour was rarely chosen in any of the four cases, consistent with the low CI in the sequence of cases (Figure 7a). However, for the agricultural sample, the effect of the highest CI (5) made colour the most frequently chosen element to change, irrespective of the level of screening of the building (Figure 7b).

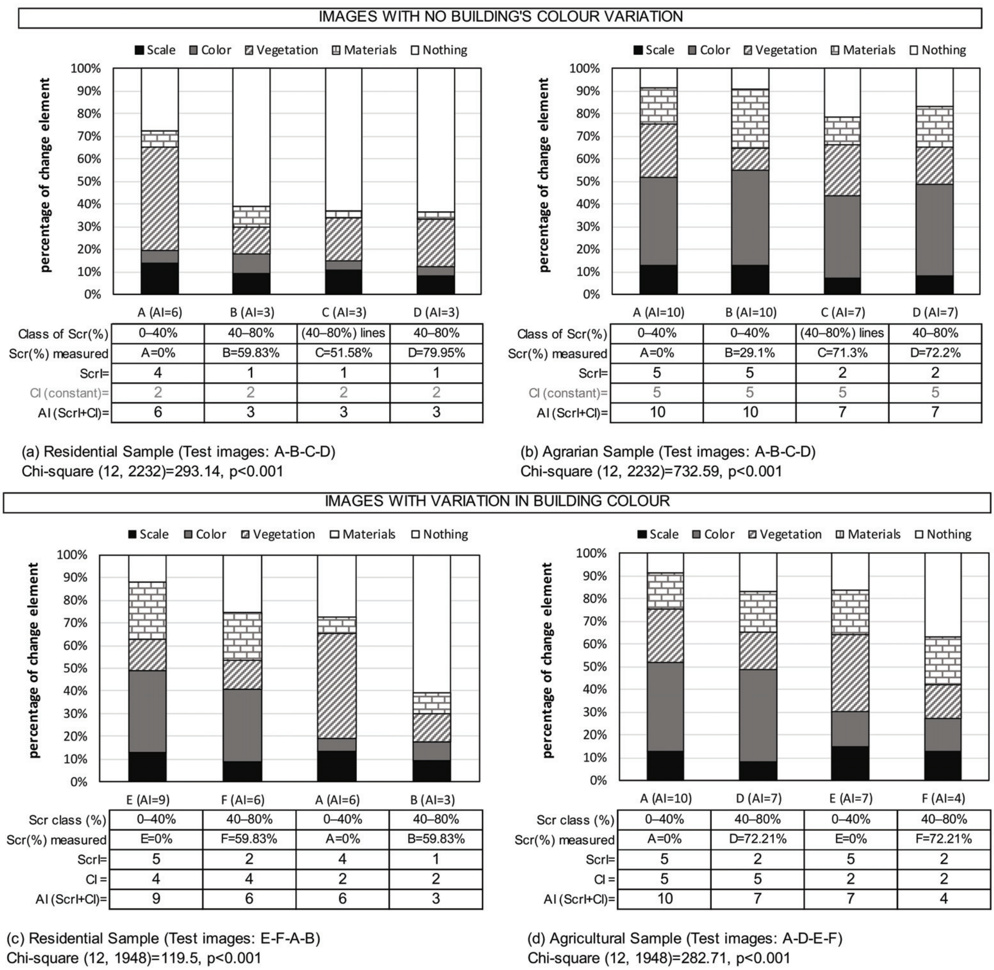

Figure 7. Results of preferences in change elements for images with no building colour variation: (**a**) Residential Sample: test images: A-B-C-D, (Figure 3) and (**b**) Agrarian Sample, test images: A-B-C-D, (Figure 4). Results of preferences in change elements for images with variation in building colour: (**c**) Residential Sample: test images: E-F-A-B, (Figure 3) and (**d**) Agrarian Sample, test images: A-D-E-F, (Figure 4).

For the sequences with variation in both variables (Figure 7c,d), the effect, with a few differences, was similar in both samples. In cases of high AI (9/10), the predominant element chosen for change was colour, occurring in cases of more discordant colour and 0% screening. In cases where the AI was lower (3), the selection of the option to change "nothing" increased in both samples.

Intermediate cases with the same AI also had a similar response in the two samples. In cases F (residential) and D (agricultural), in which colour contributed more to AI, colour was the most frequently chosen element for change. In cases A (residential) and E (agricultural), the opposite occurred, with vegetation being the most frequently chosen element for change because the impact of screening in these cases contributed more to the AI.

4. Discussion

The only results included and discussed below are the within-subject results of all the respondents for test image type, which had more statistical significance and effect [36] in the preliminary ANOVA (residential d = 1.20 vs. agricultural d = 1.45). This analysis indicates that not all the images were rated the same, and the answers depended on the study variables in each test type (screening and colour).

4.1. Rating of Vegetation Screening (Test Images A, B, C, and D)

In both samples, the linear arrangement of trees showed no significant differences with dispersed arrangement in the comparison class. This shows that respondents did not visually prefer this type of arrangement to an irregular or dispersed arrangement. Similar results were obtained by Garrido et al. [39], although these authors did not quantify the percentage of vegetation used or measure its impact.

The minimum percentage of vegetation screening for a building with a dissonant colour to start to transition towards an acceptable rating is 40%, as indicated by the obtained logarithmic model (Equation (2)). The good fit of this model is encouraging and supports the W-F law; however, a more data points would be necessary to confirm this law. Nevertheless, the goodness of the obtained logarithmic fit can be understood as an initial approximation to affirm that the relationship between the increases in a percentage of a stimulus and the detection does not follow a linear trend [38,50–52].

The increment in the rating was significant (Bonferroni tests) in the residential cases with a shift from 0% vegetation to 50% vegetation (50% increment from case A to case C) and from 30% to 70% in the agricultural cases (40% increment from case B to case C) (Figure 5). Both graphics also show a nonlinear trend in respondents' answers. Other authors reported that 40–50% shifts in visual stimuli [7,20,39] become appreciable for observers.

Similar results were obtained by Liang B. et al. [53], who conducted a study with photo simulations to analyse whether increasing tree cover in residential streets would have a measurable effect for an average observer. Their results suggested that to ensure an acceptable preference value (ratings of at least three on a five-point scale), cover should not be less than 41%. They also demonstrated that the relationship between tree cover and preference followed a curvilinear function rather than a linear function.

The chosen percentage of 40% between the screening classes proposed in this study therefore appears to be correct. Moreover, the recommended minimum of 40% vegetation to screen a poorly integrated design appears to be an efficient value [27].

It is clear in both samples or types that increasing the percentage of vegetation in front of a building significantly affects the rating of the building, irrespective of the colour of the façade and the roof. However, if the colours of the building are well-integrated, screening may not be necessary, as indicated by the ratings that were always higher than three in the residential sample (Figure 5a). Similar results were reported by García et al. [11].

4.2. Rating of the Combined Effect of Scr × C

The aggregate sum of impacts followed the same trend, irrespective of building type and respondent group, producing a decreasing linear relation between the aggregate sum of impacts and the rating of the images. The fits obtained in both Equations (3) and (4) were very good with regard to R^2 and were significant in estimating the parameters. Similar results were reported by Montero et al. [36], who supported the theory of the influence of the aggregate sum of impacts on visual perception in which the whole contributed more as a sum of parts than each part separately [54,55].

Despite this, the ratings in the residential sample never dropped to the very bad categorisation, even in the test image with the greatest impact (case E, Figure 6a). This may be due to the construction materials of both initial buildings, which clearly performed better in the residential case than in the agricultural case (case B residential, Figure 3; case A agricultural, Figure 4). In studies on the visual impact of a building based on its visual design elements, the "construction materials" study variable has been shown to have a significant contribution [11,36,44,56–58]. However, the impacts resulting from this aspect were not assessed or measured in this study.

Intermediate test images obtained similar ratings, with no significant differences in either sample. Both cases had the same overall total AI: six in cases F and A (residential) and seven in cases D and E (agricultural) (Figure 6). Buildings with a discordant colour that is partially screened (cases F (residential, Figure 6a) and D (agricultural, Figure 6b)) and a building with an integrated colour and no screening had the same effect on observer preference.

4.3. Analysis of Frequencies: Elements of Change

Although the increased percentage of screening in the foreground of a building had a positive effect in both samples (Figure 5a,b), in the agricultural case, the most discordant colour remained detectable and dissonant; therefore, this was the case that was most frequently identified by respondents as requiring changes (Figure 7b). The effect of colour as the most recognisable surface element in visual impact studies has been described by other authors [19,21,59]. When the colour and the overall built design of a construction are good, the average observer appears to want to add some vegetation (case A, Figure 7a). The literature includes works that showed an improvement in the visual preferences of respondents when the level of screening of a construction was partially increased with vegetation [24,25,60].

Although images with the same AI obtained similar ratings and showed no significant differences (cases F and A (residential) and D and E (agricultural); Figure 6a,b), the average observer can recognize which element has the greater impact, choosing colour or vegetation as the most common element of change according to their higher or lower contribution to the aggregate sum of impacts (Figure 7c,d). Similar results were obtained in previous studies, e.g., by Montero et al. [36] for scale and colour and by García et al. [11] for lines and forms.

5. Conclusions

The proposed method was shown to work well and was validated using surveys. The use of tree vegetation to screen the view of a building clearly improves the rating of the visual integration of the construction, regardless of whether trees are aligned or in dispersed arrangement. Moreover, 40% of vegetation screening appears to be the percentage after which the integration of a building starts to noticeably improve.

In the study of the vegetation–colour interaction, the colour of the building is the most significant element chosen for change when its impact is high or very high (impact of four or five for colour), irrespective of the level of vegetation screening. However, using tree vegetation for screening in these cases reduces the negative effect of the colour, increasing the probability of obtaining an "acceptable" rating for visual integration. Using vegetation in these cases is highly recommended, especially in cases in which the design cannot be improved.

The absence of vegetation in cases of façades with little or moderate colour impact (colour impacts 1–3) and high-quality finishings still results in acceptable levels of integration; therefore, the use of vegetation may be optional, although it is recommended wherever possible.

The transfer of the results of this research to the planning field can contribute to a more sustainable environment, facilitating policy recommendations. The proposed method is easy to use with minimal training and could be useful, especially in tourist destinations, where visual integration of buildings is a problem to be addressed.

Finally, the method can be used in similar rural areas, as the cognitive principles on which it is based do not depend on the working environment.

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Exploring the Spatio-Temporal Dynamics of Development of Specialized Agricultural Villages in the Underdeveloped Region of China

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Abstract: The development of specialized agricultural villages (DSAVs) is essential for rural revitalization. However, most current studies focus on the formation of specialized agricultural villages (SAVs), while the interpretation of DSAVs from the perspective of the geographical factors is still missing. In this study, we firstly employed the kernel density estimation to analyze the spatial pattern of DSAVs and then utilized the Geographic Detectors to explore which geographical factor(s) affected the SAVs of Henan, China in the formation (in 2010), steady (2011–2014), and rapid development (2015–2019) period of SAVs. The DSAVs were measured by gross product (GP), the employment rate (ER), and farmers' income (FI) of SAVs. Eleven indicators described the geographic factors in five categories: terrains, resources, locations, markets, and economy. The results showed that the spatial pattern of DSAVs was from relatively uneven in the early formation to significantly clustering in the development period of SAVs. Specialized shiitake and Chinese herbal villages clustered in the mountain–plain transition zone. The aggregation of specialized coarse cereals villages was in the hill–plain transition zone. Specialized fruit and livestock villages gathered in the plain region. Further analyses were in these regions; compared with SAVs' formation's critical factors, the importance of terrain and location factors to DSAVs was decreasing, while market and economic factors were increasing in the development period of SAVs. The strongest changing was the development of specialized shiitake villages in the mountain–plain transition zone. These findings could provide guidance for the direction of DSAVs in underdeveloped areas.

Keywords: specialized agricultural villages; geographical factor; the underdeveloped region; China

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1. Introduction

As China's urbanization thrived in the past few decades, most rural villages have begun to show signs of recession. However, specialized agricultural villages (SAVs) have shown vitality and have become spotlights in China's contemporary rural economy [1]. Specialized agricultural villages refer to rural settlements, often villages, that are established by the government, who makes the decisions about the direction of production and choice of crops—a collective agribusinessman, the output value of which constitutes the majority of that of the village [2]. Examples include those specializing in cereal, vegetable, and fruit cultivation, or even certain types of manufacturing. The dominant activity itself is often the combined result of economic incentives and cultivation history in the region [3]. According to the statistics of the Ministry of Agriculture and Rural Affairs of China, there were 60,473 SAVs in China as of 2016, of which 2398 had total annual revenues exceeding $14,082,523, and 151 were over $140,825,230 [4]. The number of specialized farming households reached 17.46 million, accounting for 80.4% of the total. The per capita disposable income in SAVs was $1982, which is 13.8% higher than nationwide [5]. SAVs have become an essential part of the core competitiveness of China's rural economy.

SAVs in China have had unique developmental characteristics. While rural specialization in developed countries, mostly estates dedicated to the production and sale of high-quality wines, rural cooperatives of specific cheeses such as in France, Spain, Italy, and Switzerland [6–8], were largely affected by transportation cost, market transaction fee, materials and technical resources, market price risks and scope, and agricultural policies [9–11], factors such as rural elites, terrains, resources, locations, markets, governments, and economic status played critical rules in the formation of SAVs in China [4,8,12,13]. At present, most studies have focused on the formation of SAVs and its influencing factors [4,14,15], the spatial agglomeration and evolution of SAVs [16,17], and the spatial continuity of crop planting and its influencing factors [18]. However, rural elites are not widespread, and their emergence is often incidental and regional [19]. On the other hand, geographical environment (such as, topography, resources, and location), and socio-economic (for example, market and economic) factors are objective and more common, and therefore are of practical significance to the formation of SAVs. Topography, resources, and location played a fundamental role in the formation of SAVs [15]. Generally speaking, low elevation, gentle slope, sufficient water resources, and fertile land support the development of large-scale commercialized agricultural production [14]. The closer a village is to the road network, the lower the transportation cost of agricultural products, which is more conducive to the formation of SAVs [8]. Market and economic foundation played a catalytic role in the formation of SAVs [15]. Market reflects the demand for agricultural products in an area. It is easier for villages around the markets to develop into SAVs [13]. The higher level of economic development and more agricultural-related enterprises may increase agricultural investments and the willingness of enterprises to upgrade production technology, which provided better financial foundation and agricultural technical support for the formation of SAVs [20]. For example, Li et al. [14] integrated SAVs data of Henan Province (China) in 2010 and applied the distance attenuation and the theory of neighborhood effects to analyze the relationship of the formation of SAVs and environmental variables (landform, location, arable land area, and labor). The study found that these environment variables decided the type of SAVs.

While these studies have shed light on the formation of SAVs in general, they offer limited guidance to the development of specialized agricultural villages (DSAVs), which occupy a substantial proportion of underdeveloped areas and are more unique than they are similar to the other specialized villages (i.e., specialized villages of processing industry, transportation industry, clothing industry, etc.). Furthermore, while the key drivers during the formation stage of SAVs may still play a part in the villages' future development, their impact will surely change with variations in economic development and market conditions. In addition, new factors may come into play in the development of these SAVs.

Thus, we must recognize that compared with the formation of SAVs, it is their continued development that contributes to inclusive rural development and helps reduce poverty in underdeveloped areas. In this regard, looking at the spatial pattern of DSAVs and finding out which geographical factor(s) affected the continued development of SAVs in the underdeveloped areas are of great theoretical and practical value. With this in mind, we used the SAV data of Henan province in the times of their initial growth (2011–2014) and rapid development (2015–2019) to explore their spatial patterns using the kernel density estimation. Then, we constructed a specialized agriculture village development index (SAVDI), quantified the geographical factors, and utilized Geographic Detector to explore the spatio-temporal dynamics of the SAVs in their agglomerates and the underlying geographical factors' influences. Our results provide a scientific basis for formulating appropriate policies for developing agricultural specialization in underdeveloped areas.

2. Study Area and Data Processing

Our study area is Henan province, which is the underdeveloped and largest agricultural province in central China (Figure 1). In 2019, Henan's total grain output was 66.95 million tons, which is more than one-tenth of China's total grain output. The agricultural output value was \$70.9 billion, and the per capita Gross Domestic Product (GDP) was \$8627.30, ranking 3rd and 17th in China, respectively. Henan province has always played the leading role in the formation and development of specialized agricultural villages. Its geography ranges from the mountains in the northwest, west, and south, to the plains in the central and eastern regions. Most of the province is in the warm temperate continental zone, while the southern part has a subtropical continental climate. The average annual temperature, rainfall, and illumination are 10.5–16.7 °C, 407.7–1295.8 mm, and 2000 h. The yearly frost-free period exceeds 250 days [21]. The climatic conditions are helpful for the growth of crops and the development of agriculture.

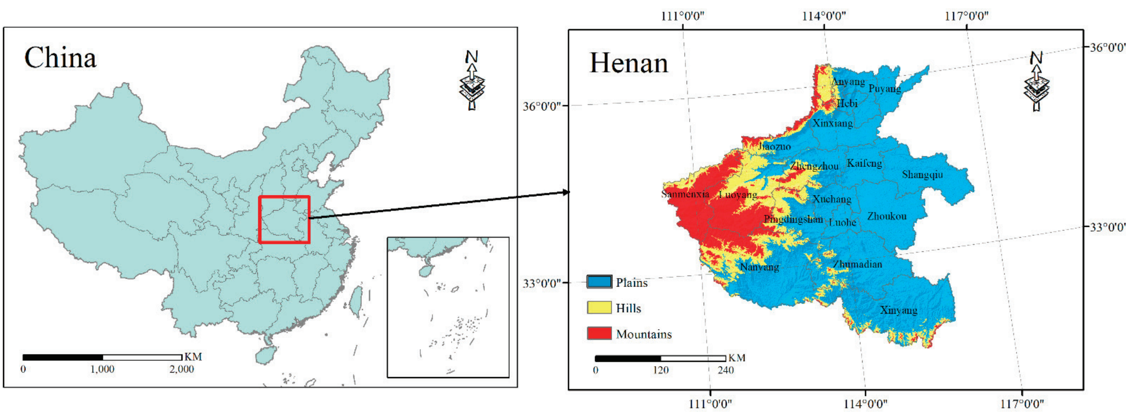

Figure 1. The case study area: Henan, China.

SAVs data in 2010–2019 were obtained from the Department of Agricultural–Rural Affairs of Henan province. Each record of SAVs contains the name, population, leading industry, total economic product, the number of employees, and per capita disposable income. From these, GP = domestic product, ER = the number of employees/populations of SAV, FI = per capita disposable income ∗ population of SAVs. Then, we calculated ΔGP, ΔER, and ΔFI of each SAV using Equations (1)–(3), and the proportion of various SAVs in 2011–2014, 2015–2019. Five types of 856 SAVs were selected as research objects since $\Delta GP > 0$, $\Delta ER > 0$, $\Delta FI > 0$, and each accounted for more than 5% of the total SAVs. Five types of SAVs were shiitakes (37.76%), coarse cereals (21.08%), fruit (12.48%), livestock (11.02%), and Chinese herbal medicine (5.31%), respectively. These SAVs were geocoded with Baidu Maps (the online map servicer of China).

$$\Delta GP = GP_m - GP_n \tag{1}$$

$$\Delta ER = ER_m - ER_n \tag{2}$$

$$\Delta FI = FI_m - FI_n \tag{3}$$

where if m = 2019, n = 2014, else if m = 2014, n = 2010, else if m = 2010, $\Delta GP = GP_m$, $\Delta ER = ER_m$, and $\Delta FI = FI_m$.

The SRTM DEM 30 m data was obtained from the Chinese Academy of Sciences Resource Environment Data Cloud Platform, and it was used to derive the arithmetic mean elevation of SAVs using the zonal statistics as a table tool in ArcGIS 10.7. The window analysis calculated the slope (window size: 2.15 km^2) with the SRTM DEM 30 m data.

The primary river data of Henan province came from the same platform; it was used to calculate the spatial distance from each SAV to its main river by the near tool available in ArcGIS 10.7. The average annual rainfall data were from the China National Meteorological Data Center to get the average annual rainfall of SAVs. Soil quality data were derived from the land–air interaction research team of Sun Yat-sen University to get the soil quality grade of SAVs. Road network data of Henan province were obtained from the Land Resources Survey and Planning Institute of Henan Province. We used it to calculate the road network distance from each SAV to its county seat, prefecture-level city center, national road, and provincial road. The population, disposable income, and the number of county enterprises were derived from statistical yearbooks.

3. Method

The study presented a data-driven framework to investigate DSAVs and explore the effects of geographical factors. The framework contained four steps: (1) measuring the DSAVs by the construction of SAVDI, (2) quantifying the potential association factors, (3) analyzing the spatial pattern of DSAVs in 2011–2014 and 2015–2019, and (4) evaluating the significantly associated factors and finding the key influencing factor on DSAVs in the SAVs agglomeration regions.

3.1. Measurement of DSAVs

Factor analysis (FA) is a statistical method for extracting common factors from variable groups. This method has been widely used in geography, ecology, and epidemiology. Compared with principal component analysis (PCA), FA better describes the correlation between the original variables [22]. In our study, FA was used to compose the SAVDI to measure the development of each type of SAVs based on three variables—gross product (GP), the employment rate (ER), and farmers' income (FI). Since there were five main types of SAVs in our study, the SAVDI was further broken down into five indices (see Table 1). SAVDI included the specialized shiitake village development index (SSVDI), specialized coarse cereals village development index (SCCVDI), specialized fruit village development index (SFVDI), specialized livestock village development index (SLVDI), and specialized Chinese herbal villages development index (SCVDI). The SAVDI in each period was computed using Equation (4).

$$\mathrm{SAVDI} = \mathrm{a} * (\mathrm{N}\Delta\mathrm{GP}) + \mathrm{b} * (\mathrm{N}\Delta\mathrm{ER}) + \mathrm{c} * (\mathrm{N}\Delta\mathrm{FI}) \quad (4)$$

where $\mathrm{N}\Delta\mathrm{GP}, \mathrm{N}\Delta\mathrm{ER}, \mathrm{N}\Delta\mathrm{FI}$ are the normalization results of ΔGP, ΔER, ΔFI. a, b, and c are the component score coefficients.

3.2. Quantification of the Potential Association Factors

Our study introduced the mean and extreme coefficients to characterize the relative situation of SAVs in its township administrative region. Each township includes many villages in China. Some villages may be SAVs; the number may be 1, 2, or 3. The mean coefficient is the ratio of this specialized agricultural village's index value to its township administrative area's average value. The extreme coefficient is the standardized deviation of the index value of SAVs in its township administrative region. The potential influencing indicators (Table 1) were constructed to evaluate the DSAVs from the terrains, resources, locations, markets, and economy. We used elevation, slope, mean, and extreme coefficients to measure terrain, average annual rainfall, and rivers' spatial distance. Soil grade was used to measure resources. Road network distance and traffic accessibility were utilized to measure economic and transportation characteristics. Market scale, market consumption capacity, and consumption level were used to calculate market characteristics such as supply and demand. GDP and the number of agriculture-related enterprises were used to measure economic development. Then, we assessed the multicollinearity of these variables by analyzing their variance inflation factors (VIF). To ensure that each first-grade index contains the appropriate variables, we used VIF <= 5 as the standard for selecting factors. The results are shown in the * indicators in Table 1, a total of five categories and 11 variables.

Table 1. Potential influencing factors on SAVs.

First-Order	Second-Order	Detailed Indicators
Terrain	Elevation	Elevation (T1) *, Mean coefficient of elevation (T2) *, Extreme coefficient of elevation (T3) *
	Slope	Slope (T4) *, Mean coefficient of slope (T5) *, Extreme coefficient of slope (T6) *
Resource	Water resource	Spatial distance from SAVs to river (R1) *, Mean coefficient of spatial distance from SAV to River (R2) *, Extreme coefficient of spatial distance to the river, Rainfall (R3) *, Mean coefficient of rainfall, Extreme value coefficient
	Soil resource	Soil quality grade (R4) *, Mean coefficient, Extreme value coefficient
Location	Distance to city	Spatial distance from SAVs to county (L1) *, Spatial distance from SAV to city
	Traffic accessibility	Network distance from SAVs to road network (L2) *, Mean coefficient of the network distance from SAVs to road network (L3) *, Extreme coefficient of the network distance from SAVs to road network (L4) *
Market	Market scale	County urbanization population (M1) *, Prefecture-level urban population,
	Degree of supply and demand	County urbanization rate (M2) *, Prefecture-level urbanization rate
	Consumption level	Disposable income of urban residents in the county (M3) *
Economy	Total output value	Mean county GDP of former 5 years (E1) *, Mean municipal GDP of former 5 years
	Number of enterprises	The number of agricultural enterprises in the county (E2) *

Note: * indicates the association indicators with VIF no more than 3.

According to the potential associated factors in Table 1, we set the independent variables in this study. The independent variables were NT1 = the normalization of mean elevation value (T1) of SAVs, NT4 = the normalization of arithmetic mean slope value (T4) of SAVs. $\mathrm{NR1} = \mathrm{NOR}\left(\mathrm{R1_i} - \mathrm{R1_j}\right)$, NR3 = the normalization of arithmetic mean rainfall value of SAVs, NR4 = the normalization of arithmetic mean soil quality grade (R4) value of SAVs. $\mathrm{NL1} = \mathrm{NOR}\left(\mathrm{L1_i} - \mathrm{L1_j}\right)$, $\mathrm{NL2} = \mathrm{NOR}\left(\mathrm{L2_i} - \mathrm{L2_j}\right)$. $\mathrm{NM1} = \mathrm{NOR}\left(\mathrm{M1_i} - \mathrm{M1_j}\right)$, $\mathrm{NM2} = \mathrm{M2_i} - \mathrm{M2_j}$. NE1= the normalization of $\mathrm{E1_j}$, $\mathrm{NE2} = \mathrm{NOR}\left(\mathrm{E2_i} - \mathrm{E2_j}\right)$. Here, NOR is the normalization function, if i = 2019, j = 2014; when i = 2014, j = 2010.

3.3. Global Moran's I

Moran's I is a measure of spatial autocorrelation of DSAVs [23]. Moran's I test of DSAVs were using NΔGP, NΔER, NΔFI, and SAVDI by Equations (5) and (6) in this study.

$$\mathrm{I} = \frac{\mathrm{N}\sum_{i=1}^{n}\sum_{j=1}^{n}\mathrm{W_{ij}}\left(\mathrm{x_i} - \mathrm{x}'\right)\left(\mathrm{x_j} - \mathrm{x}'\right)}{\sum_{i=1}^{n}\sum_{j=1}^{n}\mathrm{W_{ij}}\left(\mathrm{x_i} - \mathrm{x}'\right)^2} \tag{5}$$

$$\mathrm{Z} = \frac{\mathrm{I} - \mathrm{E(I)}}{\sqrt{\mathrm{VAR(I)}}} \tag{6}$$

where I is the Moran index; n is the number of SAVs; x_i and x_j are the NΔGP, NΔER, NΔFI, and SAVDI values of ith and jth SAV; x' represents the average value of NΔGP, NΔER, NΔFI, and SAVDI of all SAVs; W_{ij} is the spatial weight matrix. The spatial weight matrix describes the degree of position association between every two SAVs. W_{ij} = 1 means that ith and jth SAV are "neighbors"; otherwise, W_{ij} = 0. The significant differences may appear in the autocorrelation analysis using different spatial weight matrices. I > 0 means positive correlation as a whole; I = 0 means the random distribution; I < 0 means the negative correlation as a whole. VAR(I) is the variance of the global Morin index; E(I) is the expected value of the global Morin index.

3.4. Analyzing the Spatial Pattern of DSAVs

Kernel density estimation is a non-parametric method that uses local information defined by a window (also known as the kernel) to estimate a specified feature's density at a given location [24]. The kernel density estimation was utilized to analyze the spatial pattern of DSAV by Equations (7)–(9).

$$\hat{f}(x,y) = \frac{1}{nh^2}\sum_{i=1}^{n}(SAVDI_i)K(\frac{d_{i,(x,y)}}{h}) \tag{7}$$

$$K\left(\frac{d_{i,(x,y)}}{h}\right) = \frac{3}{\pi}\left(\left(\frac{d_{i,(x,y)}}{h}\right)^2\right)^2 \tag{8}$$

$$h = \delta\left[\int_{-\infty}^{+\infty} f''\left(d_{i,(x,y)}\right)^2 d_{i,(x,y)}\right]^{-0.2} n^{-0.2} \tag{9}$$

where $\hat{f}(x,y)$ is the density value of the estimated point (x, y); h represents kernel bandwidth; n is the sum of SAVDI within a certain bandwidth range; $d_{i,(x,y)}$ is the distance between the event point i and the position (x, y); K is a density function that describes how the contribution of the point i changed with $d_{i,(x,y)}$.

3.5. Using Geographic Detectors to Identify the Significant Factors of DSAVs

Geographic Detectors (GDs) are statistical methods that detect spatial differences to reveal the phenomenon's driving forces. GDs contain 4 detectors (differentiation and factor detection, interaction detection, risk area detection, ecological detection). Compared with traditional classification or partitioning algorithms such as K-means and SOM, the GDs have obvious advantages in spatial differentiation [25]. GDs have been used in land use [26], regional economy [27], public health [28], etc. In this study, we used the differential and factor detector (Equation (10)) to detect the explanatory power of the factors affecting DSAVs. The explanatory power of each factor could be interpreted with the value q. A larger q value indicates that the factor has stronger explanatory power and greater influence on the spatial pattern of DSAVs.

$$q = 1 - \frac{\sum_{h=1}^{L} N_h\sigma_h^2}{N\sigma^2} \tag{10}$$

where q represents the influencing factor interpretation of DSAVs and ranges from 0 to 1; h is a region (e.g., the prefecture-level village of this study); L is the number of areas of the type; N_h is the number of SAVs in a given area; N is the number of SAVs in the region; σ_h^2 is the kernel density variance of SAVDI in an SAV; σ^2 is the kernel density variance of SAVDI throughout regions 1, 2, and 3 in this study.

4. Results

4.1. Spatial Pattern of DSAVs

From the changing of the number of SAVs and the value of SAVDI (Section 3.1 for the calculation method) from 2010 to 2019 (Figure 2), this study found that the number of SAVs and the value of SAVDI were an obvious breakpoint in 2014. From 2010 to 2014, the number of SAVs and the value of SAVDI increased relatively flatly over time. After 2014, they have greatly increased from 2015 to 2019. Therefore, this research sets 2011–2014 and 2015–2019 as the periods for this study. The number of SAVs are 2094 (in 2010), 2500 (in 2014), and 4047 (in 2019), respectively.

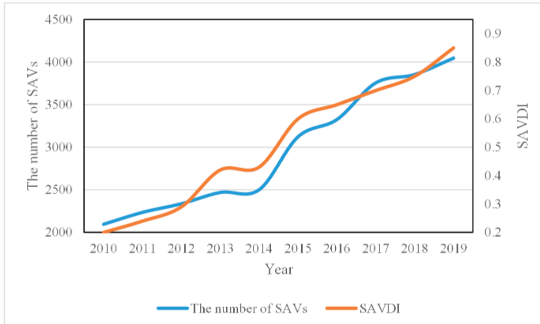

Figure 2. The number of SAVs and the value of SAVDI from 2010 to 2019.

The results Moran's I test of DSAVs were using NΔGP, NΔER, NΔFI, and SAVDI in Table 2. Spatial autocorrelation can be observed for all *z*-values above 15. This finding verified the general consistency derived from SAVDI using multi-source data.

Table 2. Moran's I test of DSAVs.

DSAV.	Global Moran's I	Z-Value	P-Value
NΔGP	0.47	19.25	0.001
NΔER	0.51	18.12	0.001
NΔFI	0.49	15.25	0.001
SAVDI	0.45	17.56	0.001

Note: The development of specialized agricultural villages (DSAVs), NΔGP, NΔER, and NΔFI are the normalization results of ΔGP, ΔER, and ΔFI. ΔGP, ΔER, and ΔFI are the changing value of gross product (GP), the employment rate (ER), and farmers' income (FI) with time for the specialized agriculture village development index (SAVDI).

The SAVDI in 2011–2014, 2015–2019 was as the dependent variables and computed by Equation (4) and the component score coefficient matrix of FA in Table 3. Here, when we calculated SSVDI in 2011–2014, a = 0.332, b= 0.211, and c = 0.635 in Equation (4). By analogy, we used the same scheme to calculate the SCCVDI, SFVDI, SLVDI, and SCVDI in 2011–2014, 2015–2019, respectively.

Table 3. Component score coefficient matrix of factor analysis.

Period of Time	Original Variables	Factors				
		SSVDI	SGVDI	SFVDI	SLVDI	SCVDI
2011–2014	NΔGP	0.332	0.258	0.102	0.155	0.752
	NΔER	0.211	0.554	0.552	0.641	0.341
	NΔFI	0.635	0.285	0.311	0.166	0.156
2015–2019	NΔGP	0.212	0.125	0.158	0.265	0.711
	NΔER	0.601	0.561	0.441	0.421	0.256
	NΔFI	0.635	0.251	0.321	0.321	0.100

Note: Specialized shiitake village development index (SSVDI), specialized coarse cereals village development index (SCCVDI), specialized fruit village development index (SFVDI), specialized livestock village development index (SLVDI), and specialized Chinese herbal villages development index (SCVDI). NΔGP, NΔER, and NΔFI are the normalization results of ΔGP, ΔER, and ΔFI. ΔGP, ΔER, and ΔFI are the changing value of gross product (GP), the employment rate (ER), and farmers' income (FI) with time.

The results of the kernel density analysis of SAVDI are shown in Figure 3. We found that SAVs were unevenly distributed in 2010 (Figure 3A), and the degree of aggregation increased from 2010 to 2019 (Figure 3B,C). The agglomeration of SAVs concentrated in the province's marginal area and then enhanced in the periphery of Luohe (Figure 3). The kernel density values were above 10.0 pcs/10,000 km^2 in the western Nanyang (region 1), Luohe (region 2), and northwestern Shangqiu (region 3) from 2010 to 2014 (Figure 3B). The SAVs clustered in Luohe, Puyang, Jiaozuo, northwestern Shangqiu, and western Nanyang from 2015 to 2019, and the kernel density values were over 13 pcs/10,000 km^2 (Figure 3C). In these two time periods, region 1 (mountain–plain area), region 2 (hill–plain area), and region 3 (plain area) are areas where hot spots of SAVs persisted, but their development capabilities are different. Specifically, the accumulation of specialized shiitake villages was in region 1. The kernel density values were above 12.0 (in 2011–2014) and 15.0 (in 2015–2019). Specialized coarse cereals villages clustered in region 2 from 2010 to 2019. Specialized fruit and livestock villages were growing in region 3 from 2010 to 2019. Specialized Chinese herbal villages agglomerated in region 1, and the kernel density value was increasing from 2010 to 2019.

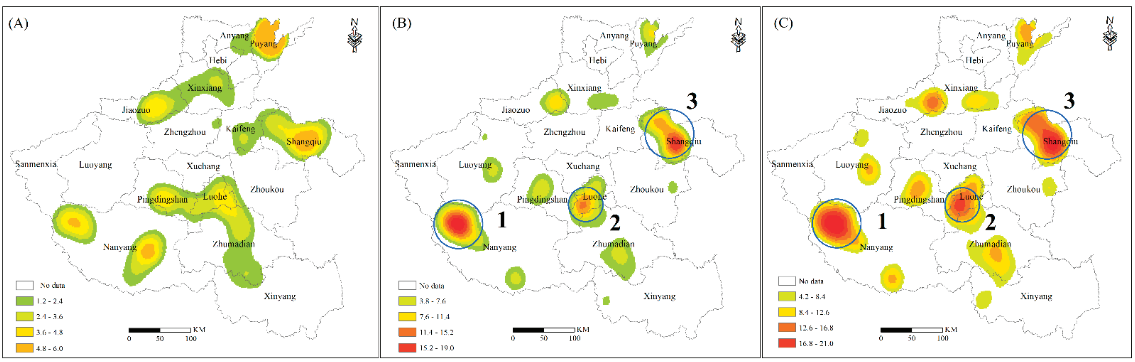

Figure 3. The results of the kernel density analysis of SAVDI in 2010 (**A**), 2011–2014 (**B**), and 2015–2019 (**C**).

4.2. Identifying the Key Influencing Factors of DSAVs

The DSAVs were affected by multiple factors. With the elimination of numerous co-linear effects, influencing factors ended up with 11 indicators in five categories: terrain, resources, location, market, and economy. As illustrated in Table 4, most of the indicators had significant ($p < 0.01$) impacts on DSAVs in the SAVs agglomeration regions 1, 2, and 3. Terrain and location factors were the key influencing factors in 2011–2014; economic and market factors were the key factors in 2015–2019.

Table 4. Geographical detector analysis results of the impact factors of SVAD.

Indicator	SAVDI (2011–2014)		SAVDI (2015–2019)	
	q Statistic	*p* Value	q Statistic	*p* Value
T1	0.1311	0.0000	0.1012	0.0000
T4	0.3158	0.0000	0.1581	0.0000
R1	0.1521	0.0000	0.0325	0.0311
R3	0.1112	0.0000	-	-
R4	-	-	0.0125	0.0221
L1	0.4120	0.0000	0.1251	0.0000
L2	0.1985	0.0000	-	-
M1	0.1421	0.0000	0.3814	0.0000
M2	0.1025	0.0000	0.1528	0.0000
M3	0.0211	0.0325	0.1645	0.0000
E1	-	-	0.4021	0.0000
E2	0.0112	0.0412	0.1514	0.0000

Note: T1: elevation value, T4: slope, R1: the spatial distance from SAV to river, R3: rainfall, R4: soil quality grade, L1: the spatial distance from SAV to county, L2: the spatial distance from SAV to road network, M1: county urbanization population, M2: county urbanization rate, M3: disposable income of urban residents in the county, E1: mean county GDP of former 5 years; E2: the number of agricultural enterprises in the county.

Geographical detector analysis results in region 1 (Tables 5 and 6) showed that the development of specialized shiitake villages was mainly affected by the distances of SAVs to the road network (q statistic = 0.4712, $p < 0.01$), the spatial distance to the county (q statistic = 0.1623, $p < 0.01$) in 2011–2014; the disposable income of urban residents in the county (q statistic = 0.4513, $p < 0.01$), and the number of agricultural enterprises in the county (q statistic = 0.2115, $p < 0.01$) from 2015 to 2019. The development of specialized Chinese herbal medicine villages was affected by the number of agricultural enterprises of the county in 2011–2014 and 2015–2019 (q statistic = 0.3258 and 0.4125, respectively, $p < 0.01$).

Table 5. Geographical detector analysis results of the impact factors of the development of specialized shiitake villages in region 1.

Indicator	SSVDI (2011–2014)		SSVDI (2015–2019)	
	q Statistic	*p* Value	q Statistic	*p* Value
T1	0.1211	0.0000	0.1010	0.0000
T4	0.1158	0.0000	0.1147	0.0000
R1	0.1521	0.0000	0.1245	0.0000
R3	0.1011	0.0000	-	-
R4	-	-	-	-
L1	0.1623	0.0000	0.1058	0.0000
L2	0.4712	0.0000	0.0812	0.0301
M1	0.1371	0.0000	0.1821	0.0000
M2	0.1125	0.0000	0.1258	0.0000
M3	-	-	0.4513	0.0000
E1	0.1123	0.0000	0.1122	0.0000
E2	0.1128	0.0000	0.2115	0.0000

Table 6. Geographical detector analysis results of the impact factors of the development of specialized Chinese herbal medicine villages in region 1.

Indicator	SCVDI (2011–2014)		SCVDI (2015–2019)	
	q Statistic	*p* Value	q Statistic	*p* Value
T1	0.2211	0.0000	0.1561	0.0000
T4	0.1350	0.0000	0.1012	0.0000
R1	0.0121	0.0000	0.0000	0.0000
R3	0.0011	0.0000	-	-
R4	-	-	0.0320	0.0221
L1	0.1214	0.0000	0.0058	0.0311
L2	0.1104	0.0000	0.1012	0.0000
M1	0.0121	0.0111	0.0032	0.0124
M2	0.0352	0.0344	0.1058	0.0000
M3	0.0214	0.0221	0.0522	0.0000
E1	0.1251	0.0000	0.2136	0.0000
E2	0.3258	0.0000	0.4125	0.0000

Note: Specialized shiitake village development index (SSVDI), specialized Chinese herbal villages development index (SCVDI); T1: elevation value, T4: slope, R1: the spatial distance from SAV to river, R3: rainfall, R4: soil quality grade, L1: the spatial distance from SAV to county, L2: the spatial distance from SAV to road network, M1: county urbanization population, M2: county urbanization rate, M3: disposable income of urban residents in the county, E1: mean county GDP of former 5 years; E2: the number of agricultural enterprises in the county.

In region 2, the development of specialized coarse cereals villages (Table 7) was impacted by the spatial distance from SAV to the county (q statistic = 0.3521, $p < 0.01$) in 2011–2014, and 2015–2019 (q statistic = 0.4114, $p < 0.01$), which was followed by the spatial distance from SAVs to a river in 2011–2014 (q statistic = 0.2521, $p < 0.01$) and the number of agricultural enterprises in the county in 2015–2019 (q statistic = 0.2411, $p < 0.01$).

Table 7. Geographical detector analysis results of the impact factors of the development of specialized coarse cereals villages in region 2.

Indicator	SCCVDI (2011–2014)		SCCVDI (2015–2019)	
	q Statistic	*p* Value	q Statistic	*p* Value
T1	0.1444	0.0000	0.1015	0.0000
T4	0.1026	0.0000	0.1145	0.0000
R1	0.2521	0.0365	0.0056	0.0311
R3	0.1147	0.0000	0.0651	0.0452
R4	0.1256	0.000	-	-
L1	0.3521	0.0000	0.4114	0.0000
L2	0.1099	0.0000	0.1789	0.0000
M1	0.0547	0.0211	0.3796	0.0000
M2	0.0158	0.0355	0.1485	0.0000
M3	-	-	0.1254	0.0000
E1	-	-	0.4388	0.0000
E2	0.1125	0.0000	0.2411	0.0000

Note: Specialized coarse cereals village development index (SCCVDI); T1: elevation value, T4: slope, R1: the spatial distance from SAV to river, R3: rainfall, R4: soil quality grade, L1: the spatial distance from SAV to county, L2: the spatial distance from SAV to road network, M1: county urbanization population, M2: county urbanization rate, M3: disposable income of urban residents in the county, E1: mean county GDP of former 5 years; E2: the number of agricultural enterprises in the county.

In region 3 (Tables 8 and 9), the largest influence factors of the development of specialized fruit villages were soil quality (q statistic = 0.2855, $p < 0.01$) and the disposable income of urban residents in the county (q statistic = 0.3477, $p < 0.01$) for 2011–2014 and 2015–2019, respectively. The second largest influence factors of the development of specialized fruit villages were the spatial distances to rivers (q statistic = 0.2111, $p < 0.01$) and county urbanization rate (q statistic = 0.1811, $p < 0.01$) in 2011–2014 and 2015–2019, respectively. Specialized livestock villages' development was mainly influenced by the spatial distances from villages to the road network in 2011–2014 (q statistic = 0.3250, $p < 0.01$). This pattern changed in 2015–2019; the key factor become the disposable income of urban residents in the county in 2015–2019 (q statistic = 0.3125, $p < 0.01$).

Table 8. Geographical detector analysis results of the impact factors of the development of specialized fruit villages in region 3.

Indicator	SFVDI (2011–2014)		SFVDI (2015–2019)	
	q Statistic	*p* Value	q Statistic	*p* Value
T1	0.0325	0.0362	0.0025	0.0488
T4	0.0012	0.0500	0.0204	0.0362
R1	0.2111	0.0000	0.1145	0.0000
R3	0.1525	0.0000	0.1741	0.0000
R4	0.2855	0.0000	0.1401	0.0000
L1	0.1117	0.0000	-	-
L2	0.1109	0.0000	0.1789	0.0000
M1	0.0547	0.0311	-	-
M2	0.1425	0.0000	0.1811	0.0000
M3	0.1845	0.0000	0.3477	0.0000
E1	-	-	0.1201	0.0000
E2	0.1114	0.0000	0.1000	0.0000

Table 9. Geographical detector analysis results of the impact factors of specialized livestock villages' development.

Indicator	SAVDI (2011–2014)		SAVDI (2015–2019)	
	q Statistic	*p* Value	q Statistic	*p* Value
T1	-	-	-	-
T4	-	-	-	-
R1	0.0045	0.0211	0.1156	0.0359
R3	-	-	-	-
R4	-	-	-	-
L1	0.1147	0.0000	0.1341	0.0000
L2	0.3250	0.0000	0.1658	0.0000
M1	0.1166	0.0000	0.1230	0.0000
M2	0.1014	0.0000	0.1552	0.0000
M3	0.1254	0.0000	0.3125	0.0000
E1	0.1030	0.0000	0.1311	0.0000
E2	0.1141	0.0000	0.1115	0.0000

Note: Specialized fruit village development index (SFVDI), specialized livestock village development index (SLVDI); T1: elevation value, T4: slope, R1: the spatial distance from SAV to a river, R3: rainfall, R4: soil quality grade, L1: the spatial distance from SAV to the county, L2: the spatial distance from SAV to the road network, M1: county urbanization population, M2: county urbanization rate, M3: disposable income of urban residents in the county, E1: mean county GDP of former 5 years; E2: the number of agricultural enterprises in the county.

5. Discussion

Studies show that the SAVs in Henan province began to form in the late 2000s and saw the steady growth in the early 2010s [2]. It was not until later that decade, when the national government diverted more attention and resources to rural development that these SAVs flourished unprecedently [15]. The average and extreme coefficients of the influencing factors of SAVs have remained stable. The average coefficients of various indicators fluctuated around 0.8, and the extreme coefficients fluctuated around 0.2 in 2010 (Table 10). SAVs converged toward regions that were relatively superior in terms of terrains, resources, and locations. However, with the improving infrastructure such as roads, rail, etc., the influencing factors on DSAVs were also changing. Compared with 2010 (during the initial stage of SAVs' formation), the importance of terrain and location factors to SAVs decreased, while the importance of market and economic factors was increasing in 2011–2014 and 2015–2019. Market and economic factors became the key factors affecting DSAVs in Henan.

Table 10. Statistical mean and extreme coefficient of influencing factors of SAVs (2010).

Indicator	Shiitake	Coarse Cereals	Fruit	Livestock	Chinese Herbal Medicine
T2	0.84	0.85	0.8	0.94	0.83
T3	0.2	0.22	0.18	0.21	0.19
T5	0.75	0.73	0.83	0.82	0.81
T6	0.16	0.18	0.2	0.22	0.23
R2	0.85	0.91	0.88	1.03	0.93
L3	0.78	0.72	0.79	0.8	0.77
L4	0.19	0.21	0.21	0.20	0.23

Note: T2: mean coefficient of elevation, T4: slope, T3: Extreme coefficient of elevation, T5: mean coefficient of slope, T6: the extreme coefficient of slope, R2: mean coefficient of spatial distance from SAV to river, L3: mean coefficient of the network distance from SAVs to road network, L4: extreme coefficient of the network distance from SAVs to road network.

The fact that the market and economic factors gradually became more critical overtime was in line with previous research on the development of rural areas at the township level [29]. With the economy's improvement, traditional geographical factors such as topography, resources, and location on economic development in agricultural regions have gradually decreased, and geographical proximity became a significant driver of economic accumulation. The importance of economic factors has steadily increased. The similarity of the findings indicates that the DSAVs at the township level or the village level and economic activities other than agriculture have gradually increased, and the importance of economic development factors has also increased.

While research pointed to market demand as the only factors affecting SAVs in China's northern plain–hill areas [4], it was for a specific time (in 2011 or 2017). Thus, it focuses on a particular section in DSAVs. However, our study of Henan province, which is also dominated by plains and hilly areas (more than 60%), points to a gradual but steady shift of importance from topography, resources to market, and economic factors. This reveals the long-term development pattern of SAVs and their changing trends at the macro time scale.

As location factors had become less important and were slowly eclipsed by market and resource factors in the development of specialized shiitake and fruit villages, we could consider relocating and merging them with small-scale underdeveloped villages. In doing so, we tap into the high-value agricultural products in a planned way. Similarly, the importance of location and resource factors to specialized coarse cereals, livestock, and Chinese herbal medicine villages was slowly surpassed by market and economic factors. The continued development of these SAVs requires that measures be taken, including in-depth analysis of the agricultural product markets, improving the quality of agricultural products, establishing smooth transportation channels for markets, etc.

Even though the key influencing factors of the development of various SAVs were similar, their respective importance was quite different. A case in point is the key factors influencing the development of specialized shiitake and fruit villages. While both were market elements, the explanatory powers and specific indicators were different. The disposable income of urban residents in the county was the key factor for specialized shiitake villages in 2015–2019 (q statistic = 0.4642, $p < 0.01$), while for specialized fruit villages, the driving factor was the county urbanization population in 2015–2019 (q statistic = 0.3275, $p < 0.05$). Therefore, when guiding the DSAVs, relevant authorities need to pay attention to the importance of the factors affecting DSAVs and the differences brought forward by change of the village types to realize the refined guidance for DSAVs.

6. Conclusions

The geographical factors play an essential role in the development of SAVs in undeveloped regions in China. However, perhaps simply due to a lack of long-term data of SAVs, few studies focused on the continued development of SAVs over a longer temporal scale. Responding to this deficiency, we integrated multi-source data, applied the geographic detector and other methods to analyze the spatial pattern of SAVs, and explored DSAVs as affected by the geographical environment in Henan Province, China. The main conclusions are as follows. (1) The spatial pattern of DSAVs presented the characteristics of aggregation in the marginal area of the provincial boundary and the significantly growing cluster in the western Nanyang (mountain), Luohe (hill–plain), and northwestern Shangqiu (plain). (2) The importance of terrain and transportation to DSAVs is decreasing, while the importance of market and economy is increasing. (3) According to the explanatory power changing of influencing factors of various SAVs in the different regions, the strongest changing was specialized shiitake villages in the western Nanyang (mountain region).

DSAVs is often affected by multiple factors, such as rural elites and rural self-development capabilities. However, it is challenging to find indicators that reflect the emergence of rural elites, rural self-development capabilities, and other factors in this research. One possible solution is to introduce new data and indicator systems to look at potential factors (e.g., availability of skilled labor, ready supply of inputs, climate change, risks and export markets) in future research. This will support decision making for the underdeveloped areas to formulate rural development strategies tailored to local conditions.

Author Contributions: The authors confirm contribution to the paper as follows: N.N. designed the research, conducted a literature review, performed data analysis, interpreted the results, and drafted the manuscript. X.L. co-designed the research framework and revised the drafts in due course. L.L. participated in the whole research processing, particularly during research design,

literature discussion, review and interpretation of analysis results, and revising and finalizing of the manuscript. All authors reviewed the results and approved the final version of the manuscript. All authors have read and agreed to the published version of the manuscript.

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Article

Counterbalancing the Development Territorial Disparities in the Implementation of the Community-Led Local Development EU Approach in Romania

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Abstract: LEADER is a rural development method based on a participative approach, which was tailored in 1991 as a complement to the traditional common agricultural policy (CAP) measures. One of its most important objectives is to reduce the differences between rural and urban areas by building on local knowledge and potential. The aim of the present paper is to identify what are the most important characteristics of the LAGs that can counterbalance the existing economic disparities in the rural regions. The research was conducted in the northwest development region of Romania (2014–2020 programming period), using the principal component analysis and the hierarchical cluster analysis. Two types of data were collected: indicators of performance, such as the number of projects contracted and jobs created, were used to assess the success of the method, while the territorial and LAG characteristics were used to explain these results. The findings confirm the presence of an unequal distribution of LEADER support in favor of the most urbanized and developed areas. However, the results also show that the experience and economic and administrative capacity of LAGs could help counterbalance the influence of the territorial features previously mentioned, and therefore to reduce the gap between them and the more developed groups.

Keywords: local development strategy; rural jobs; demographic decline; rural areas; territorial approach; area-based strategies

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1. Introduction

Rural areas cover 90% of the European Union's (EU) territory and host more than half of its population. For decades, those areas have been facing some important socio-economic and demographic challenges, such as high unemployment, population decline, migration, low levels of income, and high dependency ratios on the agricultural sector [1–3]. For those reasons, rural development became one of the most important subjects of the EU's common agricultural policy (CAP), with a strong focus on the multi-functionality of agricultural activities, economic diversification, innovation and knowledge transfer, and the resilience of cultural and environmental heritage [1]. However, as Alonso and Masot [1] argue, rural areas are struggling to achieve sustainable development using only the traditional rural development CAP's measures developed in national or regional top-down rural development programs (RDPs). They point toward a territorial imbalance in the distribution of economic resources, as the more developed municipalities, with an already existing business infrastructure can attract more investment funds compared to the more economically disadvantaged areas. Thus, in the early 1990s, the EU started to look for alternative solutions in the form of participative approaches and in the development of social capital as driving forces for the revitalization of rural communities [4]. One such solution was LEADER ("Liaison Entre Actions de Développement de l'Économie Rurale"), which became one of the most important alternative bottom-up rural development methods used in the EU in the past three decades. The approach was firstly introduced in 1991 to improve the potential of rural areas by drawing on local knowledge, initiative, and skills [5]. In its first stage (LEADER I, 1991–1994), the method was implemented in 217 pilot rural regions, while in the second edition (LEADER II, 1994–1999), the number already grew to over 900 areas. Due to its success, the method was further expanded under LEADER+ (2000–2006) to cover all types of rural areas [5]. Starting with its fourth edition, the method was financed through the European Agricultural Fund for Rural Development (EAFRD) and became a mandatory component of all rural development programs (RDP) [6]. In the most recent programming period (2014–2020), LEADER was extended under the broader concept of community-led local development (CLLD) [7]. CLLD is designed to build on the communities' strengths by offering them not only long-term funding but also the power to decide how to use it, employing a participative bottom-up approach. This transforms the local population from passive beneficiaries into genuine drivers of local development [8]. The method achieves this by enabling the local stakeholders to come together and create area-based local development strategies (LDSs) funded through the LEADER program. Thus, these multi-actor partnerships, called local action groups (LAGs), are responsible for implementing the LDSs, and therefore the method, at the local level [9,10].

From an economic point of view, LEADER receives less funding compared to the more traditional programs; thus, LAGs must concentrate on more innovative projects that help to improve the living conditions in rural areas [11]. However, those projects are more complex and harder to implement, being dependent on the existence of strong and experienced stakeholder networks in their territories [12]. The literature shows that although LAGs have contributed to the diversification of the rural economy, especially in tourism [6,13], they struggled to create non-agricultural jobs [13–16]. Contrary to the principles and objectives of the program, the results also show similar tendencies regarding the territorial distribution of LEADER support, as in the case of the more traditional rural development measures developed under the rural development plans. The more economically developed areas managed to attract more funds and create more jobs than the poorer rural and highly remote municipalities [9,11,17–20]. Concerning this issue, Canete et al. [18] argue that even though LAGs were trying to reduce these territorial imbalances, they might have produced the opposite effect, making them more pronounced.

However, despite the above-mentioned shortcomings, the program has indeed raised the quality of life in rural areas by satisfying social needs and facilitating investments in non-productive but essential projects, such as training programs, innovation support, and knowledge transfer [12,15,16]. The method made it possible to activate and to build on local knowledge [6], to engage the local actors [21], and to create sustainable stakeholder networks [22,23]. Those results, however, are strongly dependent on the experience of LAGs. Konečný [24] shows that the lack of experience (in the case of the newer EU member states) reduced LAGs capacity to successfully implement the method.

Concerns related to the urban–rural dichotomy are also raised in Romania, one of the most rural (43% of the population in 2017) EU member states (MS) [25]. The Romanian rural areas are characterized by demographic decline, a lower life expectancy when compared to the urban areas, and a low level of professional training [26]. Here the local economic development is strongly linked to the proximity to the big urban centers and the connection to the European-roads network [25,27]. Moreover, only the most developed municipalities have the institutional and economic capacity to implement projects using EU programs [25]. Pavel et al. [28] also show that the more isolated rural communities experienced the slowest recovery from the financial crises 2007–2008. Here, LEADER is at its second implementation period. The program is implemented by 239 LAGs that together manage a budget of EUR 563 million, financed through the European Agricultural Fund for Rural Development (EAFRD) [29]. Responding to socio-economic problems such as demographic decline and low levels of income, Romanian LAGs mostly focused on measures from EUs' Priority P6—"Promoting social inclusion, poverty reduction and economic development in rural areas" and Priority P2—"Enhancing farm viability and competitiveness of all types of agriculture in all regions and promoting innovative farm technologies and the sustainable management of forests" [30]. This was a similar approach to other new EU member states, which have still attributed a major role in rural development to agriculture [24]. An important consequence of this approach was a lack of focus on other important priorities, especially for supporting the shift toward a low-carbon climate-resilient economy (Priority P5) and knowledge transfer and innovation (Priority P1) [30]. Moreover, Olar and Jitea [31] have noted that many of the Romanian LAGs had failed to fully engage in core LEADER activities such as cooperation and networking and were not able to develop their own projects using alternative non-LEADER financial instruments. In this case, their success was mostly linked to their previously existing experience and the size of their team.

Thus, as stated before, LEADER should employ a territorial-based bottom-up approach and act as an alternative to the traditional national RDP, especially in the most economically disadvantaged rural areas. The literature shows that in Western Europe, the success of the program is strongly influenced by the pre-existing level of development of rural areas, remoteness, and experience of LAGs and that the method does not always produce the desired results. Therefore, on the eve of a new programming period, it is important to verify if those aspects are also true in the new EU member states, which have similar territorial characteristics as the regions previously mentioned. Thus, the paper aims to contribute to the literature by identifying the most important characteristics of the LAGs that can counterbalance the existing economic disparities in rural regions. Such results are useful for the successful future implementation of the program. Therefore, three hypotheses were formulated: H1 the implementation of CLLD is strongly dependent on territorial characteristics of LAGs such as the existence of a developed business framework in or near their territories, in line with the mainstream top-down approach critics; H2 the economic and administrative capacities of LAGs (budget, experience, and stakeholders) are important characteristics that are explaining their success. Therefore, they can be used as a method to help counterbalance the influence of the territorial features mentioned at the previous point; H3 LAGs are not fully able to follow and implement the principles of CLLD and to act as a complement to the measures of the national RDP, and thus are not able to respond to the existing economic disparities in the rural regions and demographic problems. The results should offer important lessons and insights regarding community-led local development, indicating if and how the present model needs to be adjusted in the future editions in order to create adequate responses for the demographic and socio-economic challenges in rural areas.

2. Materials and Methods

2.1. Study Area

The research was conducted in the northwest development region of Romania (corresponding to the second level of the European Nomenclature of Territorial Units for Statistics—NUTS 2). The region is characterized by a relatively large cultural and ethnic diversity, with almost a quarter of the population coming from minority ethnic groups. After Romanians, the largest ethnic groups are Hungarians, Romani, and Ukrainians. A total of 31 LAGs are active in the region (with a total budget of EUR 72 million), representing 13% of the national total. Compared to the previous programming period (2007–2013), their territory presents more homogeneous features in terms of relief, climate, demography, socio-economic and cultural environment. The area was chosen due to its similarities to other regions used in previous research [9,11]. Moreover, the region has both deep-rural territories, especially in the Apuseni Mountains, but also relatively big urban centers, serving as a suitable laboratory for the proposed objectives. However, due to the inherited limitations of a NUTS 2 development region, the results cannot be generalized to the entire EU area. Nevertheless, they are still representative for member states that joined the EU after 2004 and especially for Romania.

2.2. Data

Using the methodology established in previous similar studies [1,11], quantitative data related to the 2014–2020 LEADER edition in Romania were collected from official sources such as Romanian Statistical Yearbook [32] and LAGs own websites. Two main types of data were collected. The first set contains key socio-economic, demographic, and territorial indicators, which reflect the characteristics of the region and LAGs, while the second one contains the performance indicators related to the implementation of LDSs. Due to the lack of data availability at the municipality level, all variables were considered and calculated at the LAG level and standardized. This approach comes with some limitations. The distance to the nearest urban centers bigger than 50.000 inhabitants was calculated using the LAG administrative center as a reference, and therefore might not always be representative for all municipalities of the group. All the variables refer to the 2014–2020 programming period.

In total, more than 50 variables were considered for the analysis. A few exploratory principal component analyses were performed in order to reduce their number. The variables with the lowest explanatory factors were subsequently removed. At the end of this process, 16 variables were selected for the final statistical analysis (Table 1).

Table 1. Descriptive statistics of the selected variables.

Variable Name	Minimum	Maximum	Mean	Std. Deviation
Number. of municipalities (no)	5.00	24.00	12.12	5.04
Population (no)	11,891.00	92,558.00	39,247.13	18,851.29
Operating budget (EUR)	187,230.00	797,652.12	443,957.55	140,094.94
Number of projects (no)	12.00	53.00	30.06	11.51
Rural population/total population (%)	75.88	100.00	91.33	9.72
Number of jobs created (no)	0.00	49.00	17.22	10.84
Jobs created/jobs planned (%)	0.00	433.33	131.45	98.18
Firms/1000 pop	2.30	36.30	6.71	6.13
Young/old population ratio (%) (pop. 0–14 y.o./pop 65+ y.o.) Per 100 inhab.)	28.57	187.23	81.36	35.88
Old-age dependency ratio (%) (pop. 65+ y.o./pop 15–64 y.o.) Per 100 inhab.)	16.69	63.64	36.45	12.54
Distance to urban center (>50 k pop) (km)	9.00	86.00	35.70	19.96
Number of jobs initially planned by LAGs (no)	3.00	26.00	14.12	4.57
Paid funds (%)	14.02	70.20	46.38	14.74
Contracted funds (%)	56.13	99.81	88.75	11.44
Share of public partners (%)	15.38	35.71	24.94	5.72
Age of LAG (years)	4.00	10.00	7.80	2.70

Source: Own analysis using SPSS 20.0.

2.3. Principal Component Analysis (PCA) and Hierarchical Cluster Analysis

Principal component analysis and hierarchical cluster analysis were performed using the Statistical Package for the Social Sciences (SPSS 20.0, Armonk, NY, US, IBM Corp) in order to test the hypotheses presented at the beginning of this work.

PCA is a factorial analysis that is used to identify a small number of factors that together explain an important part of the total variance from a large number of variables. The method uses large correlations between the items to compute those factors, known as principal components (PC), that best represent the data set [33]. In this case, the PCs were selected using the computed eigenvalues (greater than 1), and the interpretation was performed using a varimax matrix that obtains factors as different as possible [33]. Subsequently, the Kaiser-Meyer-Olkin (KMO) test was used to check the validity of data in the PCs analysis. The result was 0.627; therefore, the decision to perform the analysis with those variables is acceptable [1]. The method is often used in LEADER-related studies. Masot et al. [11] used it to analyze the investments and projects carried out by Spanish and Portuguese LAGs, while in Romania, Olar and Jitea used it to analyze the quality of LDSs [30] and the multiplier effects that LAGs had generated in their territories [31].

Hierarchical cluster analysis is used to classify similar objects into homogenous groups, allowing, in this case, to empirically identify the most important characteristics that determine LAGs' success in the implementation of the LDSs [33]. The analysis was performed using the squared Euclidean distance and Ward's method in order to produce similar-sized clusters with a similar degree of tightness [33]. Hierarchical clustering requires no a priori decision regarding the number of clusters [34]. While a possible limitation of the method is the fact that there is no accepted rule regarding the number of cases, it will still be able to provide a solution even with a small sample. However, in this case, a trade-off in accuracy could be expected [33]. As in the case of PCA, hierarchical cluster analysis proved its usefulness in other similar studies [10,31,35,36].

3. Results

3.1. Principal Component Analysis Results

Five principal components were selected using the computed eigenvalues (greater than 1) (Table 2; Figure 1). Together, they explain 79.35% of the variance, a satisfactory level as shown in previous studies [1].

Component 1—Relations between LAGs and their territorial characteristics, and the implementation results (PC1).

The first component explains 26.9% of the total variance and deals with the relations between the LAGs characteristics and the number of projects implemented. The results show a strong positive correlation between the number of projects implemented by LAGs and their operation budgets and experience. They are also correlated with territorial characteristics such as population and number of municipalities. Finally, there is a negative correlation with the share of the rural population, suggesting that those areas have implemented, on average, fewer projects than the more urbanized LAGs.

Table 2. Results of the principal component analysis.

PC	Eigen Values	% Variation Explained	% Variation Accumulated	Indicators and Correlation with the PCs (The Most Discriminant Variables, Above ± 0.3)
PC1	4.308	26.926	26.926	Number. of municipalities (no) 0.944 Population (no) 0.910 Operating budget (EUR) 0.908 Number of projects (no) 0.803 Rural population/total population (%) −0.714 Jobs created/jobs planned (%) 0.316 Age of LAG (years) 0.576
PC2	2.585	16.155	43.081	Number of projects (no) 0.401 Number of jobs created (no) 0.938 Jobs created/jobs planned (%) 0.682 Firms/1000 pop 0.651 Distance to urban center (>50 k pop) (km) −0.366 Contracted funds (%) 0.492
PC3	2.279	14.245	57.326	Firms/1000 pop −0.565 Young/old population ratio (%) −0.908 Old-age dependency ratio (%) 0.839 Distance to urban center (>50 k pop) (km) 0527
PC4	2.254	14.086	71.412	Jobs created/jobs planned (%) 0.439 Paid funds (%) 0.897 Number of jobs initially planned (no) −0.871 Contracted funds (%) 0.512
PC5	1.270	7.938	79.350	Distance to urban center (>50 k pop) (km) −0.332 Share of public partners (%) 0.814 Age of LAG (years) 0.586

Source: own analysis. Extraction method: principal component analysis. Rotation method: varimax with Kaiser normalization.

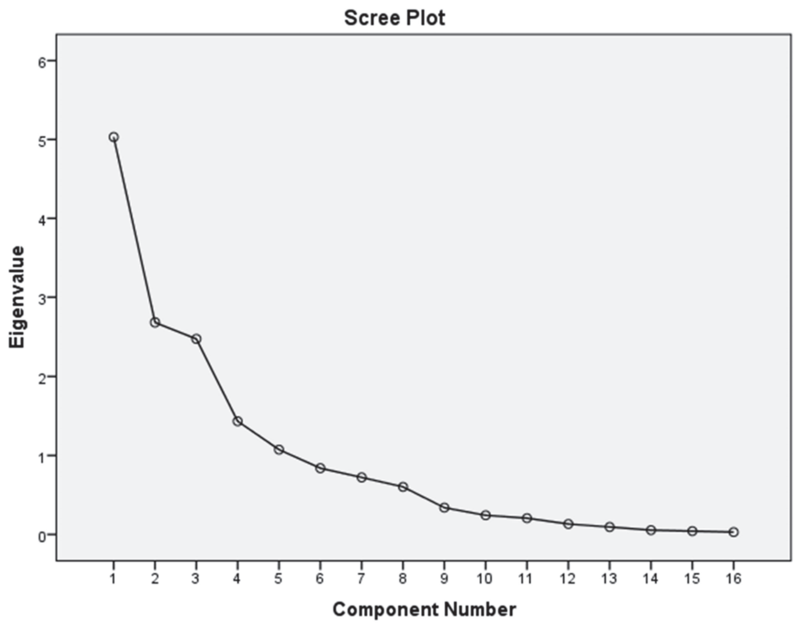

Figure 1. Scree plot. Own analysis. Extraction method: principal component analysis. Rotation method: varimax with Kaiser normalization.

Component 2—Factors that explain the success of LDS implementation (PC2).

The second component (16.15% of variance) explains the factors that influence the success of LDS implementation. Most of the variables that show LAG performance (such as the number of projects financed, share of contracted funds, and number of jobs created in the territory) are positively correlated with the number of firms present in the territory (per 1000 inhabitants) and negatively correlated with the distance to the nearest urban center. Therefore, this PC shows that, in general, the best results are obtained by the LAGs that already have or are located near a developed business framework.

Component 3—Relations between the social and economic variables (PC3).

The third PC shows how the variables discussed at the previous point (namely the distance to the nearest urban center and the business framework) are influencing the social characteristics of the rural areas. Thus, in general, LAGs that are more remote from big urban centers are experiencing more acute demographic problems and have a weaker business framework.

Component 4—Expectations versus reality (PC4).

The fourth component shows a negative correlation between the number of jobs initially planned by LAGs and their success rate in this regard, suggesting that LAGs have failed to correctly anticipate the needs or potential of the territory, or, contrary, they failed to meet their proposed objectives.

Component 5—Links between remoteness and partnership (PC5).

The last PC shows that, in general, the LAGs that are closer to big urban centers have a larger territory (therefore more public partners) and more experience. This can be explained by the fact that LAGs initially appeared in those areas, and only in the second LEADER edition started to be active in the more rural territories.

3.2. Hierarchical Cluster Analysis Results

Cluster analysis reveals three cluster types in the region (Table 3, Figure 2).

Table 3. Hierarchical cluster analysis results.

Variables	Cluster 1	Cluster 2	Cluster 3	Mean
Number of municipalities (no)	17.75	13.00	7.58	12.12
Population (no)	61,939.88	40,367.27	23,091.83	39,247.12
Operating budget (EUR)	618,171.04	470,906.25	303,112.27	443,957.55
Number of projects (no)	39.88	33.09	20.75	30.06
Rural population/total population (%)	81.15	91.86	97.65	91.33
Number of jobs created (no)	18.25	20.00	14.00	17.22
Jobs created/jobs planned (%)	178.68	140.37	91.79	131.45
Firms/1000 pop	7.35	5.85	7.08	6.71
Young/old population ratio (%)	96.79	65.51	85.62	81.36
Old-age dependency ratio (%)	32.09	43.07	33.29	36.45
Distance to urban center (>50 k pop) (km)	26.38	40.55	37.50	35.70
Number of jobs initially planned (no)	14.25	14.91	13.33	14.12
Paid funds (%)	45.03	47.37	46.38	46.38
Contracted funds (%)	90.01	92.36	84.61	88.75
Share of public partners (%)	26.41	25.49	23.46	24.94
Age of LAG (years)	9.00	9.18	5.75	7.80

Source: own analysis. Extraction method: cluster analysis. Squared Euclidean distance. Ward linkage.

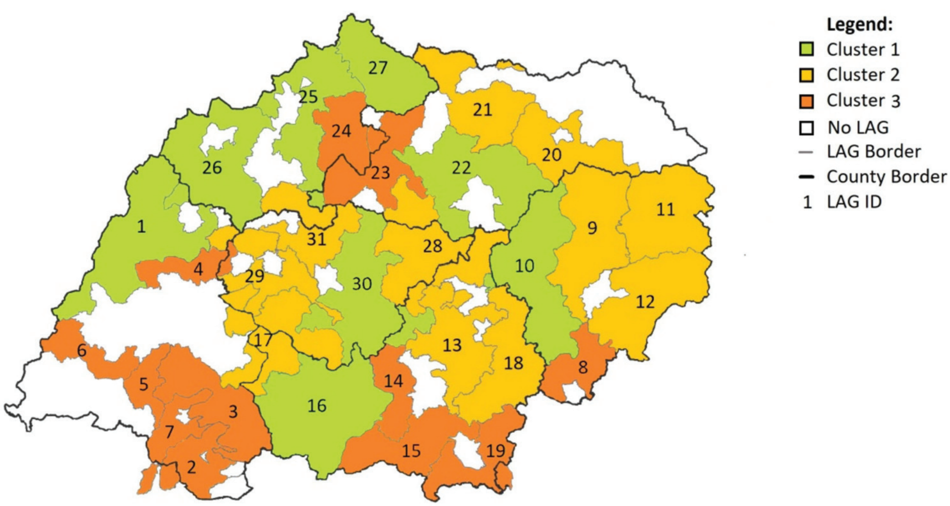

Figure 2. Source: own analysis. Extraction method: cluster analysis. Squared Euclidean distance. Ward linkage.

Cluster 1. LAGs with best results (CL1, 8 LAGs).

The first cluster groups the LAGs with the best performance regarding the implementation of local development strategies. On average, they have implemented 40 projects, almost double compared to the ones from Cluster 3, and have created more jobs than initially planned. They are characterized by a large territory and population (more than double the amount of municipalities and almost three times the population of Cluster 3), high operating budgets, and a somewhat developed business framework. However, probably the most important characteristics are their location (closest to urban centers) and urbanization level (highest of the three clusters).

Cluster 2. LAGs with moderate results (CL2, 11 LAGs).

The LAGs from the second cluster have obtained similar results regarding the contracted and paid aids and the number of created jobs, such as those from CL1, but, overall, have implemented fewer projects. They have an average size and operating budget, and although they are located farthest away from important urban centers.

Cluster 3. LAGs with the lowest performance (CL3, 12 LAGs).

The LAGs from CL3 are the smallest (both in terms of size and budget), the most ruralized, and the least experienced. They have the lowest performance regarding the number of projects and job creation, being the only ones who have created fewer jobs than originally planned. Most of them are new organizations formed during the most recent CAP programming period.

4. Discussion

As stated at the beginning of this work, the revitalization of rural areas through means of economic diversification, improvement in the quality of life, inter-sectoral cooperation, and demographic stabilization are some of the core objectives of CLLD [4]. Thus LEADER aims to use its specific characteristics to complement the traditional CAP aids and even to serve as an alternative to them in the most rural and remote areas. However, as some scholars have shown, the program was not always successful in this regard. Some regions from Spain and Portugal experienced a similar situation as in the case of CAP aids, meaning that the most urbanized LAGs and municipalities had managed to attract significantly more funds at the expense of the more remote and underdeveloped areas [11]. As a new CAP programming period is getting closer, and with it a new edition of LEADER, it is important to check if this situation is also happening in new EU member states, such as Romania. Moreover, the present work aimed to identify some important features of LAGs that help counterbalance such territorial imbalances. Thus, three hypotheses were formulated and tested. The first hypothesis (H1) stated that the implementation of CLLD is strongly dependent on LAGs' territorial characteristics, such as the existence of a developed business framework in or near their territories; thus, in Romania, it is not able to solve the mainstream top-down approach critics. The assumption is verified by the results of the first two PC (PC1 and PC2). This territorial imbalance is further emphasized by PC3 and the results of the cluster analysis, showing that the success of the method is highly dependent on the available private investment [18]. The results are in line with those signaled in the older EU member states [9,11,17–20]. From this perspective, similar to the RDPs, LEADER continues to increase the disparities between the more developed LAGs and those considered less attractive to investment, questioning the capacity of the method to create real, sustainable development.

However, there are other important features of LAGs, highlighted in the first PC and cluster analysis, such as the experience and economic and administrative capacities of LAGs. In this sense, LAGs from the CL1 are enjoying a greater capacity to successfully implement their LDSs, given by their much higher operating budget and experience, especially when compared to those from CL3. Moreover, the LAGs from the second cluster (CL2) have reported similar results regarding the contracted funds, paid aids, and number of jobs created, although they are the farthest away from important urban centers. This suggests that these aspects can be seen as a counterbalance to the influence of the territorial features mentioned at the previous point, thus confirming H2. The results are also in line with those presented in previous studies [20,24,31,37]. Konečný [24] argues that LAGs from the newer member states had both fewer resources and lack of experience, which represented important barriers in the implementation of LEADER, while Patkós [37] highlights the importance of continuity in the implementation of LEADER. Moreover, Olar and Jitea [31], in a study conducted in the same region, pointed toward the LAGs' age as one of the main characteristics that enable LAGs' success in creating lasting multiplier effects in their territories. This is more evident when considering that the same groups (those created in the 2014–2020 programming period) had the poorest results in both studies. As stated before, LAGs need to mobilize and build on local knowledge; thus, the lack of human capacity and experience could represent a serious challenge when dealing with a complex methodology [38]. Contrary, the presence of such assets could be a decisive factor in enabling the success of LEADER. In the next CAP programming period, LAGs should look for alternative financial instruments to complement the existing ones, and therefore, to strengthen their economic capacity and to be able to not only maintain their team but also to hire additional experts. The increase in the administrative capacity and the experience already accumulated should allow the more remote LAGs to close the distance between them and the peri-urban groups.

The results are also implying that LAGs are not able to fully implement the principles of CLLD, thus verifying the H3. LEADER is disproportionately favoring those areas with an already dynamic economic environment, while, as Olar and Jitea [30] are pointing out in a study on the same region, they are still employing similar measures as those from the national RDP. However, Dargan and Shucksmith [23] showed that the national and regional authorities have, in general, a different vision regarding the needs of rural areas. In the view of the top-down policies, the innovation is often approached from a technological and product perspective, without the social dimension promoted by LEADER. However, in order to achieve the best results, LAGs need to interact with and complement the RDPs, not copy them [39]. Therefore, the situation raises questions regarding the method's capacity to address the territorial needs and to create resilient rural areas and calls for a serious rethinking of the LEADER delivery approach. Cañete et al. [18] are arguing that this situation could be addressed in the very design of the program by favoring in the selection criteria LAGs with smaller and more remote municipalities. However, this solution can only lead to limited results if the core principles of LEADER will not be successfully employed. In this sense, the participative approach is crucial. Previous studies in the region underlined the importance of private and NGO partners for the successful implementation of the program. In general, the non-public stakeholders are engaging in more innovative projects, while the public ones are contributing mainly to the economic and administrative capacity of the groups [31]. However, as the same authors are pointing out, only the experienced LAGs are able to fully engage their local actors. Moreover, the public partners still retain an important degree of influence in the settlement of LDSs, a fact illustrated by the high number of measures from Priority 6B (fostering local development in rural areas). On average, 35% of the measures were allocated to this priority (measures associated with public partners), compared to the 20% in Priority 6A (that mostly deals with job creation). This situation calls for improvements regarding LAGs' accountability and transparency [22]. They should build on the existing local knowledge in order to find the right opportunities for their territories, as shown in previous studies [12,15,16]. The local actors could be stimulated by being involved in networking and cooperation activities with other LAGs, which represent an opportunity to introduce them to new good practices models [40]. However, this will prove to be difficult in countries with a low participative culture [41,42], such as Romania.

Another important shortcoming in the implementation of the CLLD in Romania is represented by the absence of measures tailored to address problems related to demographic decline and rapid aging of the rural population. Multiple factors are at the root of this reality. Probably the most important one is the traditional model of evaluation employed by the management authorities. This approach allows an easy way of quantifying the results of LAGs based on indicators such as the number of jobs created and budgetary execution. However, taken in isolation, it might paint a false image. The failure of meeting the assumed objectives could lead to penalties, not only in the next selection of the LDSs but also during the transition period. Therefore, this might force some LAGs to lower their targets and to abandon the territorial-based approach in favor of a "success-based" strategy by selecting the measures that are the easiest to implement. This situation requires a rapid rethinking of the present evaluation model by also considering LAGs' results regarding social capital and innovation. This should allow them more liberty in designing LDSs, and better responses to the above-mentioned challenges [16].

However, in some cases, LAGs themselves do not understand the real needs of the territories and are failing to address them in LDSs [30]. In this case, LAGs are limiting their responses to the more traditional RDP measures such as "the setting up of young farmers" while disregarding measures related to education and knowledge transfer. Navarro-Valverde et al. [43] are pointing out that the inability to implement the principles of the area-based approach is proof of a top-down vision in both the cases of LAGs and the management authorities. In recent years, the management authorities attempted to address the lack of diversity of LDSs by allowing and encouraging LAGs to create and employ "atypical measures" [44], which are measures that are not similar to those from the national RDP. A total of 12 out of the 31 LAGs from the region opted to implement such instruments. In total, 14 measures were created, dealing with the promotion and creation of local identity and brands, quality schemes, knowledge transfer, and the development of social and environmental capital. Although not directly aimed at solving the problems of sparsely populated areas, this approach could represent an important milestone for future policies. Konecny et al. [45] emphasize the necessity of such measures in order to truly fulfill the needs of the territory, arguing that without them, the essence of CLLD ceases to exist. Thus, LAGs should remain truthful and embrace the core principles of the participative bottom-up approach promoted by LEADER in order to respond to the more specific local threats [46]. Moreover, in the next programming period, LAGs should also focus on finding additional non-LEADER instruments in order to create multi-funded strategies. This approach should allow them even more liberty in designing and implementing initiatives that are better suited to the territorial needs [47].

5. Conclusions

The objective of the present paper was to verify whether or not LAGs that can counterbalance the existing economic disparities in the rural regions and, under the principles of community-led local development, are managing to revitalize Romanian rural areas by implementing tailored sustainable strategies in their territories. The results show that in many cases, the method falls short of this objective. LAGs success is not only dependent on internal factors such as their experience and resources but is also highly influenced by external variables such as the presence of highly urbanized areas near their territory. The dependence on previously established business infrastructure reduces the capacity of the more rural areas, which were the primary target of the program from its very beginnings, to benefit from LEADER support and remain competitive, worsening the territorial imbalance. The top-down approach tendencies, lack of vision, and experience in both the cases of LAGs and the management authority are further limiting the success of CLLD in the region. This shows the incapacity of the method, in its present form of implementation, to respond to the problems of the sparsely populated areas, raising questions regarding its potential to create resilient rural territories. This calls for a serious rethinking of the LEADER delivery approach and evaluation models. However, the results also suggest a potential solution for reducing the aforementioned disparities. In this regard, the experience and the economic and administrative capacity of LAGs are proving to be crucial and should allow the more remote LAGs to close the gap between them and the more developed groups. This is especially important now, in the eve of a new programming period and in the case of the former socialist countries, where the rural space was highly affected. Moreover, this should help strengthen the relations between small municipalities and other local stakeholders, allowing them to apply for and implement projects that otherwise would exceed their individual economic capacities to support such initiatives [25]. In the next CAP programming period, better results can be obtained by favoring the disadvantaged areas both in the resource allocation and in the selection process and by putting even more emphasis on core LEADER principles such as the involvement of the local stakeholders in decision-making solution delivery.

The study has some important limitations. Due to its focus on a NUTS 2 region, the results cannot be generalized to the entire EU area, being representative only for Romanian and the new EU member states. However, the study complements previous research conducted in Western Europe, so together help building a more complete image.

In addition, the results highlight some important solutions to the issues identified in the mentioned literature. The study is also limited by the small number of cases (31 LAGs), which might reduce the accuracy of the methods. Future research is advisable to be conducted at the municipality level, and with a broader scope, by also considering the distribution of support from each EU rural development priority. This will offer better insights into the distribution of LEADER aids and ultimately lead to more tailored solutions.

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Article

The Territory of Valle del Jerte-La Vera and Its Tourist Development (Extremadura, SW Spain)

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Abstract: At the end of the 20th century, tourism was positioned as an activity capable of diversifying and reactivating the economies of rural European areas, which were experiencing problems of demographic regression and a high rate of ageing. Subsequently, with the emergence and promotion of new models of tourism consumption, the provision of rural tourism facilities has increased, as is the case in the north of Extremadura. This study analyzes, through the use of a descriptive and analytical method, the distribution of the demographic, socioeconomic and heritage variables existing in the tourist territory of the Valle del Jerte-La Vera region in order to interrelate them with the tourist supply and demand in this area. The results allow us to observe that Valle del Jerte-La Vera is promoting tourist activities, with the promotion and implementation of better lines of action for the reception of travelers, in such a way that they favor the increase in the economic income, and these factors are capable to maintain the existing population, thus facilitating the development of rural areas.

Keywords: rural tourism; travelers; overnight stays; Extremadura

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1. Introduction

In the middle of the 20th century, tourism developed significantly, and it was consolidated as a mass phenomenon [1–3]. In Spain, the tourism sector has been evolving over the years to adapt to the new needs and demands of travelers and began to play an important role in the country's economy from the 1960s onwards, with the "sun and beach" tourism model, given its territorial conditions. Subsequently, in the late 1980s and early 1990s, this model declined and deteriorated [4] due to the uncontrolled increase in the number of tourists concentrated in the same tourist destination. This caused the problem of overcrowding and triggered a crisis in the coastal areas due to a change in the preferences of travelers, who began to opt for short-stay trips to destinations close to cities and in areas that were not very developed. In recent decades, technology, the great variety of accommodation and the discovery of new places have played an important role in this process. All of this has favored inland tourism, which is developed away from the coasts, and its offer is oriented towards the enhancement of heritage, cultural and/or natural resources [5–7]. In this way, there has been a commitment to the development of new tourist destinations, mostly in rural areas, in which little transformation of the territory and a wide range of natural and cultural enclaves predominate [8,9], promoting quality tourism, the seasonal diversification of the supply and the extension of the latter to the interior of the peninsula [10].

Rural areas have come to diversify their uses, and, in many of them, the predominant activity has become tourism based on leisure activities that take advantage of the resources and products of each area, generating their development. This has given rise to the appearance of different types of tourism (nature tourism, green tourism, ecotourism, agrotourism, adventure tourism, cultural tourism, alternative tourism, etc.) and the inclusion of different activities, such as gastronomy, horse riding, hunting, fishing, other sports, cultural and historical visits, etc. [11]. Thus, in rural areas, tourism has become a strategic sector for their wealth, establishing itself as an activity that can complement other traditional activities, such as agriculture, livestock farming, crafts or small industry. Its contribution to the gross domestic product (GDP) is important, as well as to the creation of employment and to the capacity to dynamize visitor flows throughout the year, favoring the seasonal diversification of the tourism demand [12], especially in rural areas affected by depopulation and the growing crisis in their productive model. Tourism is contributing to the positive economic growth and the revitalization of disadvantaged or isolated areas, as well as to the maintenance or growth of their populations [13–15].

In Spain, one of the tourist destinations that has benefited the most from the changes in tourist habits, has been the region of Extremadura [16]. Since 2000, the number of travelers in the region has increased by 35% (the Spanish average is 41.29%), higher than destinations, such as Castilla y León (32.92%) or the Canaries (24.97%), and, consequently, it has experienced a 40% increase in overnight stays (much higher than the Spanish average of 25%) and a 54.9% increase in the number of establishments. However, the contribution of tourism to the GDP is still below the Spanish average (12.4%), although it is the economic sector whose contribution to the GDP is growing the most in the region [17].

In recent years, the new desires of travelers, and their search for experiences, rather than stays, have highlighted the need to increase investment towards a qualitative improvement in tourism [18]. In fact, in recent decades, the European Union (EU) has promoted a series of actions and economic policies aimed at developing tourism and agrotourism in rural areas through national and European policies with structural funds or specific initiatives, such as INTERREG or LEADER [15,19–22], for its transformation into a complementary activity to the agricultural income in areas affected by depopulation [23,24]. In this sense, one of the areas in Extremadura that is receiving the most attention is the Valle del Jerte-La Vera tourist area, the study area of this paper, as it has rich natural and cultural resources that can be exploited for tourism and is one of the areas with the highest demand for travelers in the region.

In the following, taking into account the above considerations, the literature review section is presented. Following this, the methodology used for the development of the research is established, as well as the delimitation of the study area. Section 3 shows the results obtained. These are discussed in Section 4, together with the conclusions extracted.

Literature Review

In general terms, the typology of tourism in rural areas has many common characteristics, as established by several authors [14,25–28]. It is a type of tourism that is developed in rural areas with little massification, with a quality cultural and natural offer, linked to the rural space [29], contributing as an activity for the local development of rural areas, thus maintaining the existing population, in order to avoid a rural exodus [30,31]. Due to the space in which this tourism takes place, it can be complemented by other types of tourism [32], such as ecotourism or nature tourism, mountain tourism, adventure tourism, agrotourism, cultural and historical tourism, religious, astronomical, ornithological, hunting, gastronomic, wine tourism, etc.

Taking into account these types of tourism, many of them have been developed in the region of Extremadura, with the mainly highlighted cultural tourism, nature tourism and gastronomic tourism [33]. Nowadays, there is a greater demand for other activities, such as those linked to agricultural activities, which is why agrotourism has been developed in many areas of the region of Extremadura [34,35].

Several authors [22,36] have analyzed tourism activities in this area, mainly in Valle del Jerte, providing information on the profile and interests of visitors, as the case of Millán [37], who has analyzed the rural travelers, stating that "rural tourism requires integration with its environment and its people, because rural tourists are looking for more than just lodging, they are looking to soak up the colors, flavors and smells of the rural environment. The balance between the ecological, socioeconomic and cultural systems of the area guarantees the offer of an attractive product, when combined with adequate lodging infrastructures and specialized and personalized attention".

Engelmo et al. [38] have analyzed the aid from European funds, such as LEADER, and affirmed that this territory benefits from its proximity to the capital of the country and presents a widely developed offer promoted by all local agents, based around its emblematic agricultural production, the cherry tree, and the natural heritage with figures of protection, such as the Garganta de los Infiernos Natural Reserve.

From the point of view of tourism marketing and promotion initiatives, studies of Mediano and Vicente [25], Fyall et al. [39] and Di Clemente et al. [40] highlight, where they state that a good promotion and a tourism marketing make the area known, and this will increase the attractiveness of the area [25,39–41]. Other authors [42,43] analyze tourism marketing activities, taking into account the characteristics of the demand, since one of the objectives of the marketing is to meet the needs of travelers. Linked to the tourism promotion, in recent years, Valle del Jerte-La Vera has been established as a smart tourist destination, in order to develop a greater digitization, sustainability, accessibility, quality or innovation that generates an increase in tourism demand and also has an impact on improving the perception of the destination and the tourist experience.

In view of the above, the aim of this work is to analyze the tourism sector in the tourist territory of Valle del Jerte-La Vera, to obtain information about tourism activities from 2018 to the present day and its relationship with the socioeconomic, demographic and heritage variables, which will allow us to identify the resources this territory possesses and whether these are a key element for the development of its tourism activities.

2. Materials and Methods

At the methodological level, this study gathers the relevant information related to the tourist, demographic, socioeconomic and heritage activities of the tourist territory Valle del Jerte-La Vera, alphanumerically and cartographically. This information is analyzed through the descriptive method [44–46], which allows us to perform the territorial characterization of the area, in order to determine whether its resources serve as a focus of attraction for travelers. As Gómez [47] states, "descriptive studies seek to specify the properties, characteristics and important aspects of the phenomenon under analysis". It should be noted that the use of this methodology was adopted, in order not only to collect information on its characteristics, but also to be able to use these results in subsequent studies.

2.1. Study Area

The study area of this research (Figure 1) is the tourist territory Valle del Jerte-La Vera, located in Western Spain, specifically, in the Autonomous Community of Extremadura. Within the Extremadura region, this tourist territory borders the tourist territories of Valle del Ambroz-Tierras de Granadilla to the northwest, Plasencia to the southwest and the Reserva de la Biosfera de Monfragüe to the south, while the rest of its perimeter borders the provinces of Ávila and Toledo.

The tourist territory of Valle del Jerte-La Vera covers an area of 1258.61 km^2 and has a perimeter of 189 km. It also includes a total of 30 municipalities, of which 11 belong to the Valle del Jerte region and 19 to the La Vera region. This tourist territory, together with 14 others, brings together the 388 municipalities that constitute Extremadura and represent the territorial demarcation of the tourist territories established by the Directorate General of Tourism of the Junta de Extremadura, which is used in this study as the spatial scope of action for the design of the different tourism policies in the region [48].

The Valle del Jerte-La Vera territory has a total of 34,456 inhabitants, making it the third least populated tourist territory, although it has a population density of 27.4 inhabitants/km^2, above the regional average (25.5 inhabitants/km^2). In terms of variables, such as the ageing index and the youth index, the average for this territory is 328.3% (24.9% regional) and 10.4% (113.2% regional), respectively, which highlights the advanced ageing of the population, a highly characteristic and concerning aspect of Extremadura's mountain areas.

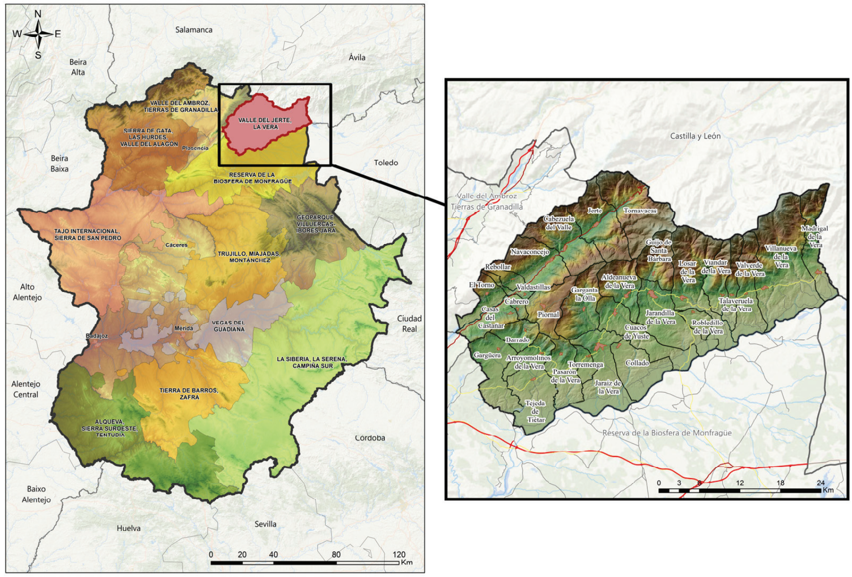

Figure 1. Map showing the location of the tourist territory of Valle del Jerte-La Vera.

It should be noted that access to the area is by land, as the only existing means of communication in the area is roads. The roads that provide access to the area are divided into various levels, including national roads (N-110), various regional roads (EX-119, EX-203, EX-213, EX-392, etc.), provincial roads and other types of regional roads. Tourism and means of transport, together with their infrastructures, are intrinsically linked, since, without travel, there is no journey [49]. In this way, the means of transport and their means of communication are some of the driving forces that allow tourism to function.

With regard to the physical environment, it is a predominantly mountainous territory, with markedly differentiating characteristics. Due to its natural and scenic values and the biodiversity of its surroundings, this territory contains protected natural areas (45.93% of the protected hectares of the tourist territory). In terms of climatic characteristics, this area is conditioned by its relief and orography, given that the mountain ranges prevent the incidence of northerly winds and favor those from the Atlantic Ocean, which generates cold winters and mild summers. All of these characteristics give the territory a high level of landscape, climatic and natural richness, which attracts tourists.

2.2. Databases

The most important point in the methodological process (Figure 2) of this research is the construction of the cartographic and alphanumeric databases, which were developed after the review of the documentary sources and the selection of the data necessary for the analysis.

Firstly, a cartographic database was created from the polygonal cartography layer of the municipalities obtained from the National Cartographic Base 1:200,000 (BCN200) of Spain's National Geographical Institute. This layer was used to obtain, as tabular information, the 30 municipalities belonging to the area under study and corresponding to the tourist territory of Valle del Jerte-La Vera delimited by the Tourism Observatory of Extremadura and the Junta de Extremadura (Figure 3).

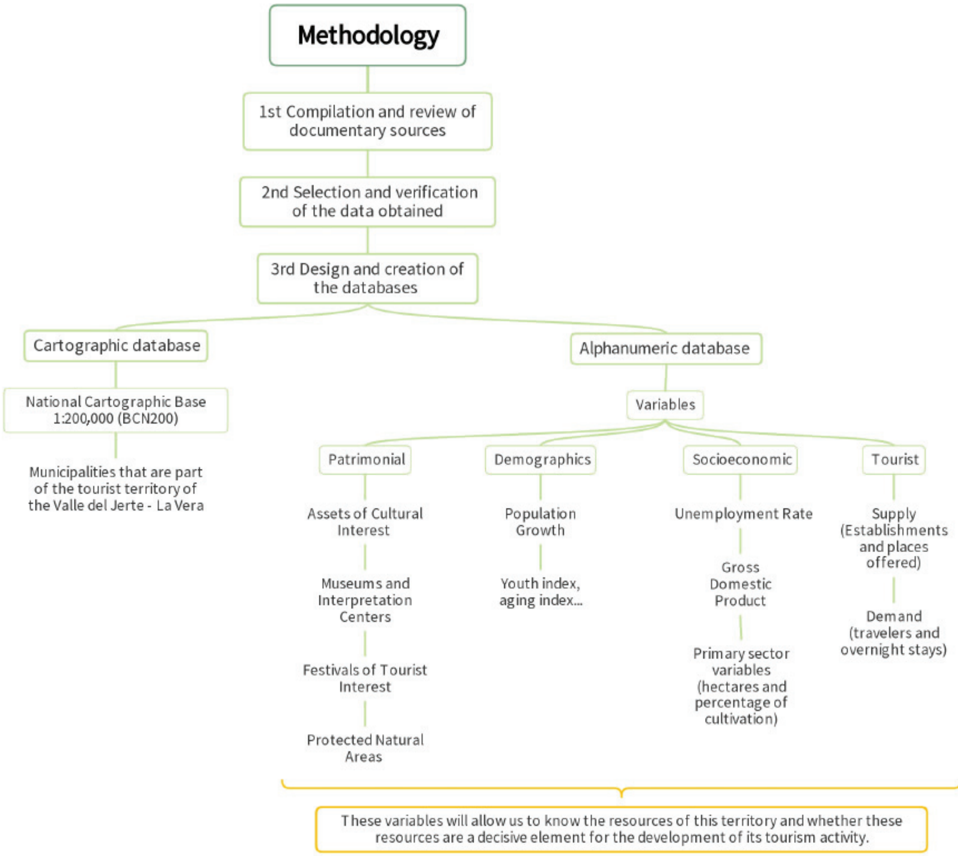

Figure 2. Methodological scheme.

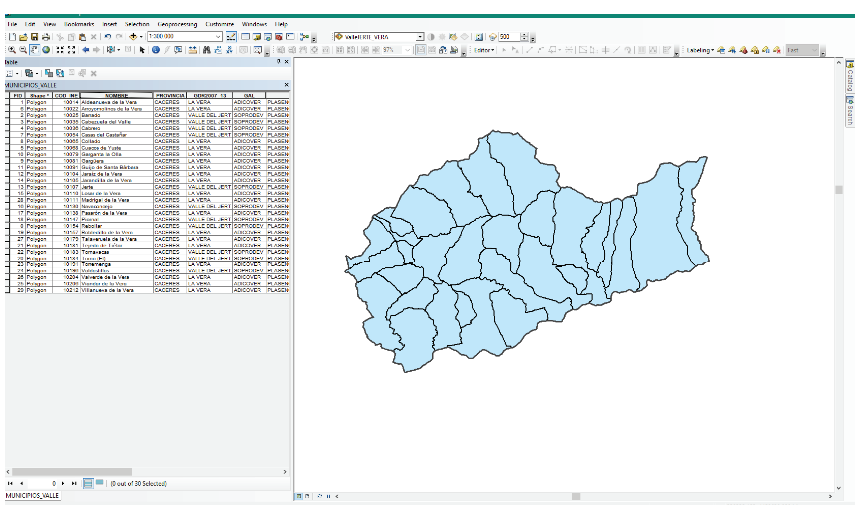

Figure 3. Polygonal layer of the municipalities of the tourist territory with alphanumeric information.

Then, alphanumeric databases were designed and created, according to heritage, demographic, socioeconomic and tourism variables.

The information on heritage resources, both cultural and natural, was collected. These resources were as follows.

- Assets of Cultural Interest. The database of immovable assets registered in the Register of Assets of Cultural Interest of the Ministry of Culture and Sport of the Spanish government was consulted, and the information was completed with that obtained from the Extremadura Observatory of Culture.
- Museums and Interpretation Centers. Information was obtained from the Extremadura Observatory of Culture and, in the case of the Interpretation Centers, those established on the Extremadura Tourism website were updated.
- Festivals of Tourist Interests. Data were downloaded and updated from the Spatial Data Infrastructure of Extremadura and the Extremadura Observatory of Culture, as these festivals are an element of attraction for tourists in the region.
- Protected Areas. Information on the protected natural areas of Extremadura, European Ecological Network NATURA 2000, was obtained from the Extremambiente website of the Junta de Extremadura.

With regard to the demographic variables, the evolution of the population of each of the municipalities that constitute the tourist territory was analyzed. Furthermore, the ageing index, the youth index and the migratory balance were calculated in order to ascertain the variation in the population of this area.

Then, the socioeconomic variables and the gross domestic product (GDP) for 2019 were analyzed, and the unemployment rate (July 2021) and other variables, related to agriculture (hectares and percentage of cultivation, etc.) in the area, relating to 2019, were downloaded from the Socio-Economic Atlas of 2021 of the Extremadura Statistics Institute.

Finally, with respect to the tourism sector, the tourism supply and demand for the years 2018, 2019, 2020 and 2021 were studied. On the one hand, we studied the data on the supply of tourist infrastructures, the number of establishments and the existing vacancies per establishment in each municipality of the tourist territory, obtaining all of the establishments from the Register of Tourist Companies of the Directorate General of Tourism of the Regional Government of Extremadura. Taking these into account, those establishments that completed the occupancy surveys for each of the years were analyzed and grouped into three types of accommodation: hotels (hotels, hostels and guesthouses), non-hotels (tourist flats, hostels and campsites) and rural (rural flats, rural hotels and rural houses and other buildings dedicated to the agritourism sector, located in rural areas). On the other hand, in the case of tourist demand, the variables of total, national and international travelers and overnight stays were used, also provided by the Directorate General of Tourism of the Junta de Extremadura and by the Tourism Observatory of Extremadura. The data on travelers and overnight stays were structured according to the type of tourist accommodation, by month and corresponding year. It should be noted that tourist demand had to be analyzed for Valle del Jerte-La Vera as a whole, since the values at the municipal level were estimated, in order to obtain the data for tourist territories, regional territories, etc.

All of these variables (Figure 2) were linked to the cartographic database, in order to understand in greater detail, the reality of the territory of study.

3. Results

3.1. Territorial Characteristics

Over the last century, according to data from the National Institute of Statistics of Spain (NIS), the demographic evolution of the Valle del Jerte-La Vera territory, on par with the rest of Extremadura, has not been positive. Figure 4 shows how the total population of the territory has lost more than 3600 inhabitants over the last 20 years, with a slight stagnation in 2010 and 2011.

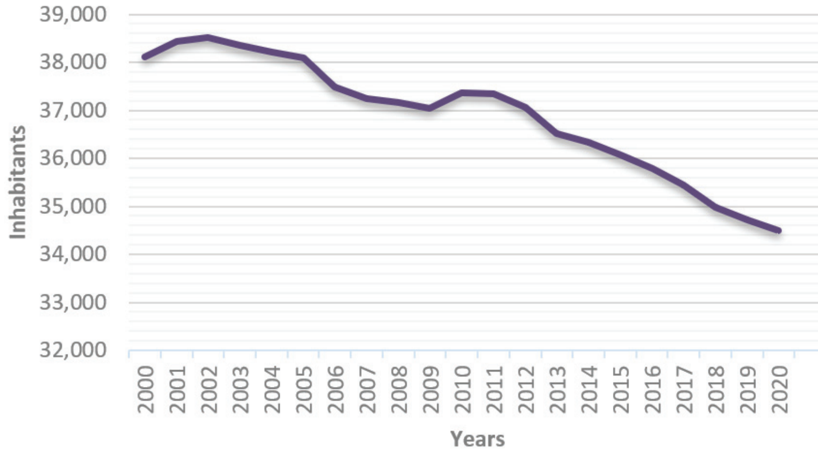

Figure 4. Evolution of the population (2000–2020) in the tourist territory of Valle del Jerte-La Vera.

Considering the population figures by municipality, it is worth mentioning that, in the last decade, practically all of the municipalities in the study area experienced a reduction in their population, reaching values of more than −23% in the case of Valverde de la Vera. Moreover, Collado de la Vera and Gargüera stand out, with their populations increasing by 15.5% and 44.7%, respectively, both with figures of between 150 and 200 inhabitants. Equally, there are municipalities which, in the last 20 years, have increased their numbers of inhabitants, such as Navaconcejo (2.9%), Torremenga (5.8%) and Villanueva de la Vera (6.9%). It is noteworthy that, at present, these municipalities do not have more than 2200 inhabitants.

According to the distribution of the population by municipality, Jaraíz de la Vera contains the largest number of inhabitants (6499 inhabitants), followed, with less than half, by Jarandilla de la Vera (2843), Losar de la Vera (2658) and Cabezuela del Valle (2141), among others. Thus, the municipalities in this area are characterized by a low population concentration, with 19 municipalities below the 1000 population threshold, of which only seven have more than 500 inhabitants. The population density is 27.38 inhabitants/km^2, which is higher than the regional average (25.45 inhabitants/km^2). There are marked contrasts in the territorial distribution of the population, with 12 municipalities showing values well above the regional average, including Jaraíz de la Vera (103.88 inhabitants/km^2), Aldeanueva de la Vera (54.09 inhabitants/km^2), Cabrero (48.72 inhabitants/km^2) and Torremenga (48.27 inhabitants/km^2). These high values indicate an intensity of population that is due more to the small surface area of their municipalities than to the volume of the resident population. Moreover, in terms of variables, such as the ageing index and the youth index, the average for the tourist territory is 328.3% (113.2% for the region) and 10.4% (24.9% for the region), respectively, which highlights the advanced ageing of the population, much more significant in the mountain areas. Moreover, in relation to this, the birth and death rates reflect a low birth rate, which almost reaches 4‰, compared with almost 7‰ in the region as a whole, and a high mortality rate (18‰—six percentage points higher than the regional mortality rate, which is 12.3‰). It is necessary to take into account the migratory balance, as this area's population increased by 275 inhabitants in 2020, an aspect that may be due to the increase in the population registered in the municipality as a result of the pandemic. Thus, due to the population density, advanced ageing and the small number of inhabitants living in these municipalities, this territory has a markedly rural character.

From the socioeconomic point of view, in recent years, the activity in Valle del Jerte-La Vera has increased, showing a great difference by sex and with the percentage of active women being much lower than that of men. In terms of the GDP, corresponding to the year 2019, most of the municipalities had a GDP of more than EUR 7000/inhabitant, with Robledillo de la Vera standing out, with more than EUR 42,000/inhabitant, as well as Valdastillas, with values close to EUR 31,000/inhabitant. At the bottom of the ranking are Collado de la Vera (EUR 6429/inhabitant), Rebollar (EUR 6389/inhabitant) and Gargüera (EUR 5932/inhabitant). Looking at the unemployment rate, only six municipalities (Gargüera, Valdastillas, Robledillo de la Vera, Cabrero, Valverde de la Vera and Talaveruela de la Vera) exceed the regional rate (13.9%). This percentage is higher, considering the rate for the study area (11.5%), which is exceeded or equaled by 11 of their 30 municipalities.

In terms of sectors of activity, the primary sector, specifically agriculture, still plays an important role for the employed population. According to the Socio-Economic Atlas of Extremadura for the year 2021, whose data correspond to the year 2019, a total of 16,168 cultivated hectares are concentrated in this area, of which 10,691 are rainfed and 5477 are irrigated (Figure 5). A more detailed analysis of their distribution by municipality shows that Jaraíz de la Vera, Navaconcejo, Losar de la Vera and Cuacos de Yuste have more than 1000 cultivated hectares, while others, such as Robledillo de la Vera, Gargüera, Viandar de la Vera and Guijo de Santa Bárbara, do not reach 200 hectares. The distribution of dry and irrigated hectares is closely related to the presence of watercourses in the municipalities bordering the territory of the Reserva de la Biosfera de Monfragüe, which results in a greater presence of irrigated cultivated hectares in the southeast of the territory. The most representative crops in Valle del Jerte-La Vera are fruit trees (7864 ha), mainly cherry trees, followed by industrial crops (3565 ha), with pepper for paprika as the main crop, and olive groves (3308 ha).

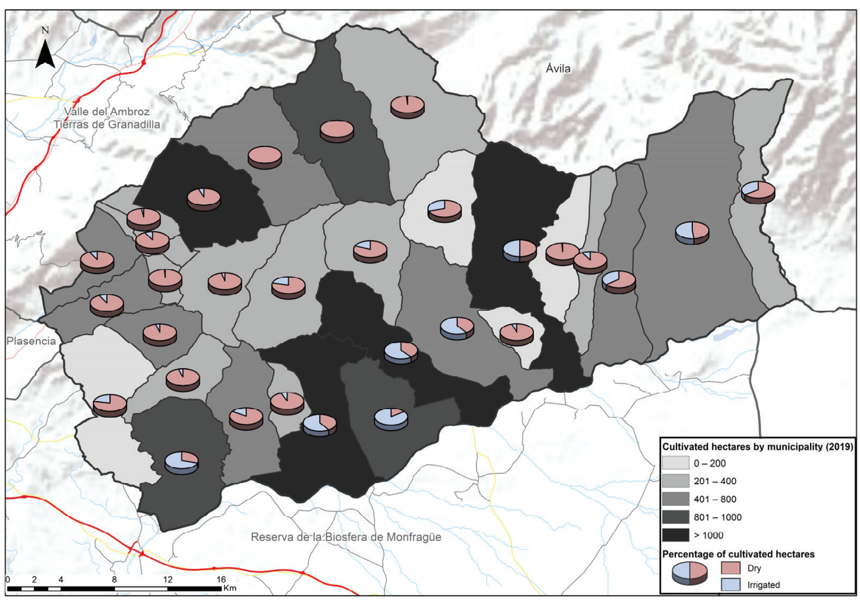

Figure 5. Map of the cultivated hectares and their typology by municipality.

Nowadays, the percentage of the population employed in the service sector has increased, largely due to tourism and, in many cases, to the implementation of economic diversification projects, such as those subsidized through the EAFRD and the LEADER method. Linked to this, their development strategy is closely related to endogenous products, as is the case for cherries in Valle del Jerte and paprika in La Vera.

In terms of heritage resources, numerous civilizations have passed through Extremadura throughout history, with their cultural legacy extending to the present day. This, together with the great natural and scenic diversity of the environment, means that there is high heritage value. This is why the territory has a large number of cultural resources, some protected and others to be protected, with a large extension and quantity of natural resources spread throughout the territory.

The following map (Figure 6) shows which municipalities in Valle del Jerte-La Vera have the highest number of cultural heritage elements. The area has a total of 19 assets of cultural interest, concentrated in municipalities, such as Cuacos de Yuste and Pasarón de la Vera, while 17 municipalities have none. In addition, the area is home to 15 museums, with Cabezuela del Valle and Garganta la Olla with several museums each, while 17 municipalities have no museums at all. The number of interpretation centers is smaller, with only six in Valle del Jerte-La Vera. Taking these three heritage-related elements into account, 11 of the 30 municipalities do not have any of these typologies.

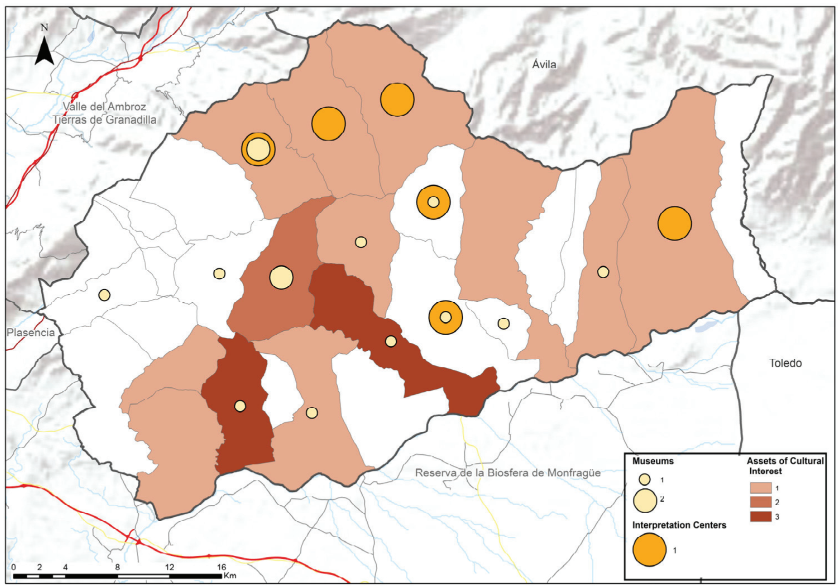

Figure 6. Map of the assets of cultural interest, museums and interpretation centers.

In Valle del Jerte-La Vera, there are several festivals of tourist interest, including the Cherry Blossom Festival, of national tourist interest, which covers the entire area of Valle del Jerte. This festival is one of the main tourist attractions, as this valley has more than two million cherry trees, which, when in bloom, give rise to a unique spectacle and landscape. The festival also tries to reflect the life of the whole region, of a land with an agricultural tradition and a star product, the cherry. To this end, all types of activities are organized to showcase the region's culture, gastronomy, traditions and way of life.

Furthermore, of national tourist interest is the Jarramplas festival, which is held in the municipality of Piornal. Of regional interest are Los Escobazos, in Jarandilla de la Vera, Los Empalaos, in Valverde de la Vera, and El Peropalo, in Villanueva de la Vera. All of these festivals are characterized by representing special moments in the lives of their populations, by reproducing manifestations related to religion, rites, fights, etc., in such a way as to provide a better understanding of the customs of these municipalities.

In terms of natural heritage, the Network of Protected Areas of Extremadura is composed of the Network of Protected Natural Spaces of Extremadura, under 10 protective figures (natural park, nature reserve, natural monument, protected landscape, area of regional interest, ecological and biodiversity corridor, Periurban Park for conservation and leisure, site of scientific interest, singular tree and ecocultural corridor) and the European Ecological Network Natura 2000, with special protection areas for birds (SPAs) and sites of community interest (SCIs), singular tree and ecocultural corridors, the latter called special areas of conservation (SACs) following the publication of the management plans in Decree 110/2015, of 19 May, which regulates the European Ecological Network Natura 2000 in Extremadura [50]. These protected areas occupy more than 1,250,000 ha in our region, of which 57,806 ha are located in the tourist territory of Valle del Jerte-La Vera. The following map (Figure 7) shows a spatial representation of the Network of Protected Natural Spaces in the study area.

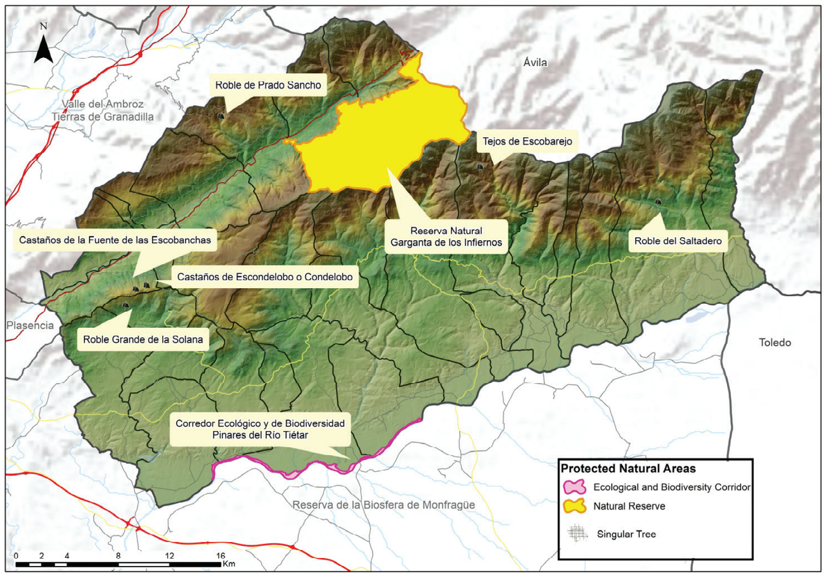

Figure 7. Map of the Network of Protected Natural Areas.

According to the European Ecological Network NATURA 2000 (Figure 8), there are two SPAs in Valle del Jerte-La Vera. These are the Lesser Kestrel Colony SPA in Jaraíz de la Vera, which covers an area of 33.17 ha and is characterized as an urban SPA, and the Río y Pinares del Tiétar SPA, which extends through numerous municipalities in the area. Moreover, the SACs are areas where the necessary conservation measures are applied for the maintenance or re-establishment of natural habitats and/or species populations. The Valle del Jerte-La Vera territory has four SACs: Sierra de Gredos and Valle del Jerte (69,528.61 ha), Monasterio de Yuste (13.81 ha), River Tiétar (4321.03 ha) and Rivers Alagón and Jerte (3131.70 ha).

The Valle del Jerte-La Vera area has a large number of water resources of considerable importance, among which the Garganta de los Infiernos stands out [29,51]. This is home to more than 10 natural pools, characterized by their shape (small natural pits called "marmitas"), due to the erosion of water on the granite rock of the area over millions of years. Other gorges in the area are the Garganta de las Monjas, near Cabezuela del Valle, the Garganta de las Nogaledas, near Navaconcejo, the Garganta de Alardos, in Madrigal de la Vera and the Garganta Bohonal, between Piornal and Valdastillas. There are also other bathing areas, such as Las Pilatillas, in Garganta la Olla and El Lago, in Jaraíz de la Vera.

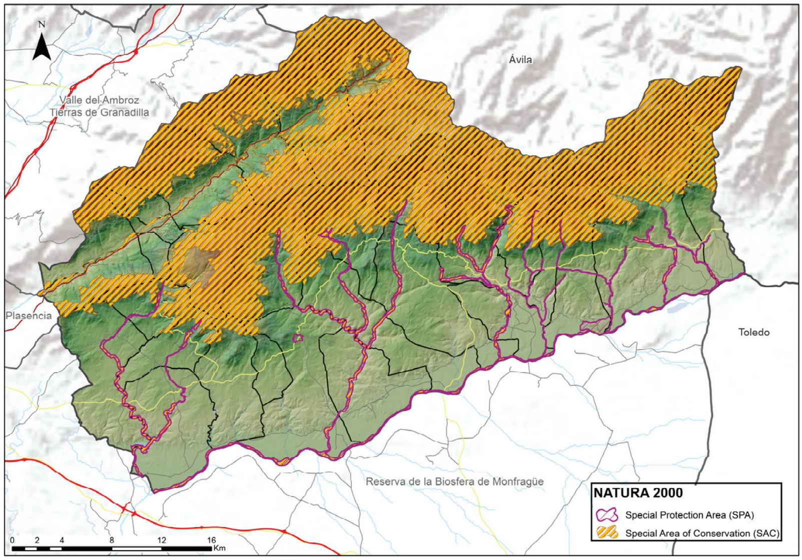

Figure 8. Map of the European Ecological Network Natura 2000.

3.2. Tourism Characteristics

Over the last few years, Valle del Jerte-La Vera has consolidated its position as the tourist territory in the Extremadura region with the highest number of accommodation establishments and vacancies offered. Moreover, and taking into account the type of establishment owner, as will be explained below, in this area, there is a large number of female promoters, especially in rural and non-hotel accommodations. Analyzing its tourist supply and demand, taking into account the open establishments that responded to the occupancy surveys requested by the NIS, there were 315 accommodations offering a total of 8578 bed places in 2021. In terms of the number of establishments, it is followed by the tourist territory of Sierra de Gata, Las Hurdes and Valle del Alagón, to the west of Valle del Jerte-La Vera, with 224 accommodations, and the city of Cáceres, with 216; moreover, Badajoz, the main city of Extremadura, only offers 27 accommodations. In terms of bed places, it is followed by Cáceres, which has less than half as many as Valle del Jerte-La Vera, with a total of 4146 bed places, and Valle del Ambroz–Tierras de Granadilla, with 3908 bed places. At the bottom of the list is Geoparque Villuercas-Ibores-Jara, with almost 1390 places.

With regard to its evolution during the four years of study, in Valle del Jerte-La Vera, both the number of accommodation establishments and the number of bed places offered have increased (Figure 9). In the case of the number of tourist accommodation establishments, hotel establishments have maintained their numbers throughout the period; equally, there has been a strong growth in rural accommodations, from 193 in 2018 to 209 in 2021, followed by non-hotel accommodations, which has increased progressively from 2018, with a total of 48, to 2021 with 59. This is due to the opening of 17 tourist flats in the area, as hostels and campsites have maintained their numbers. In relation to the number of vacancies offered by these tourist accommodations, the largest number is offered by non-hotel establishments (444)—specifically, tourist flats; this is followed by rural accommodations (244), while the number of vacancies in hotel establishments remains the same.

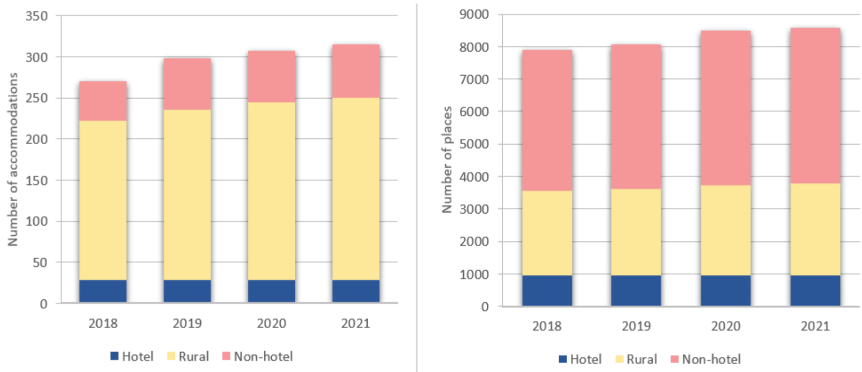

Figure 9. Graphs of the distribution of the number of accommodations and bed places offered by typology.

It can be seen how rural accommodations take precedence, being, in many municipalities, the only existing typology (Figure 10). This predominance is practically generalized in all of the municipalities of Valle del Jerte-La Vera, although, in municipalities, such as Talaveruela de la Vera, the number of rural accommodation establishments is equal to the number of hotels. In terms of the total number of establishments, the largest number is concentrated in Navaconcejo (34), followed by Jarandilla de la Vera (33); moreover, the majority of municipalities, i.e., 18, have fewer than 10 tourist establishments.

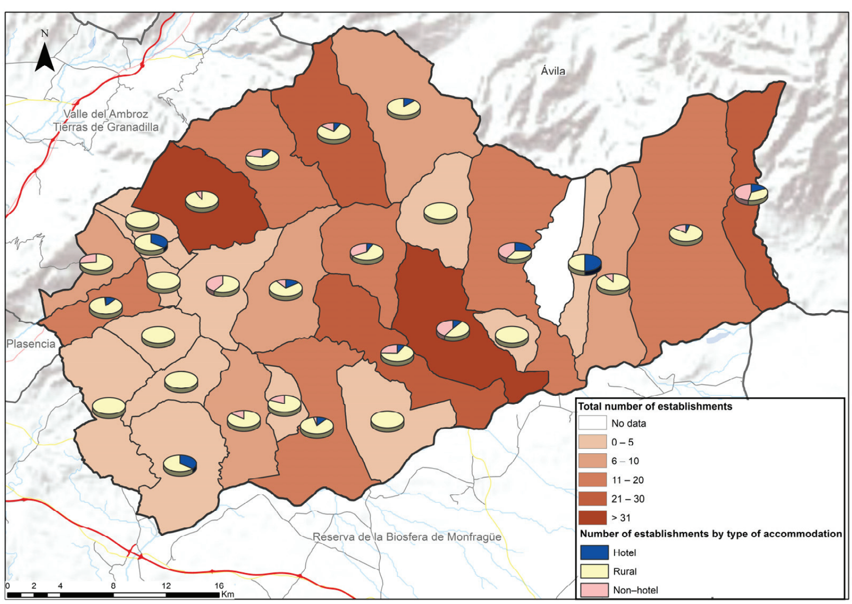

Figure 10. Map of the number of accommodations and their typologies by municipality.

With regard to the number of bed places offered (Figure 11), although the largest number of bed places is of the non-hotel type, by municipality, rural-type bed places predominate. Thus, in 21 municipalities, there is a greater number of bed places offered in rural accommodations. In addition, Valdastillas is particularly noteworthy, with a predominance of hotel accommodations. Overall, the largest number of bed places is concentrated in Jarandilla de la Vera, with 1656, followed by Losar de la Vera with 1101, while 10 municipalities in this area offer less than 50 bed places in their tourist accommodations.

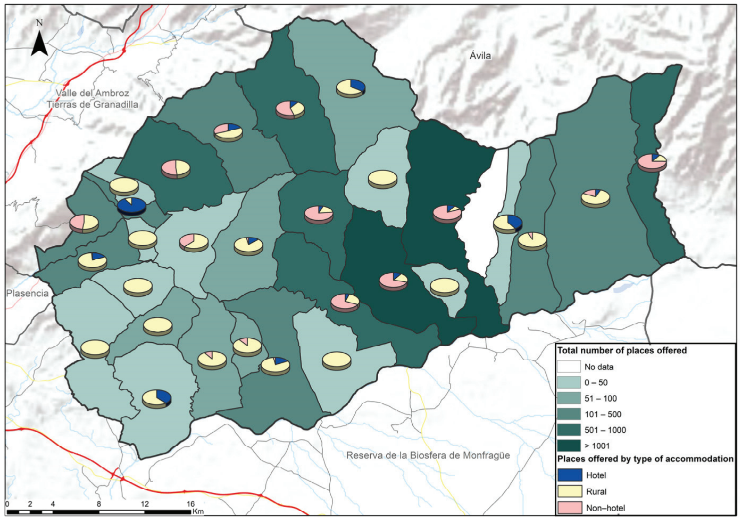

Figure 11. Map of the number of vacancies offered and their typologies by municipality.

Taking into account the data referring to the supply of tourist infrastructures in the tourist territory of Valle del Jerte-La Vera, specifically the number of establishments classified in the Register of Tourist Enterprises of the Directorate General of Tourism of the Regional Government of Extremadura, there were a total of 450 accommodations, of which 315 issued their responses to the occupancy survey to the NIS in the year 2021. This reflects the high degree of involvement of tourism entrepreneurs working in this territory. In this tourist territory, there is a high volume of rural accommodations (309), followed by non-hotel accommodations (97), and a small amount of hotel accommodations, which do not exceed 45 establishments. Analyzing the type of owner or proprietor of the tourist accommodations (Table 1), it can be seen that there is a practically an equal distribution between men (150), women (145), business groups, institutions and organizations (155), the latter being slightly higher. In non-hotel accommodations, there are more women than men serving as owners of the establishments; however, in the rest of the typologies, the number is lower. Closely related to the high number of women owners of tourist establishments is the support and funding of the LEADER and PRODER initiatives for women in rural areas, providing them with the opportunity to obtain employment and supplementary income [52], so that tourism has become a dynamic activity in these areas.

Table 1. Establishment owner and types of accommodations.

	Hotel	Rural	Non-Hotel	Total
Business group, institution or organization	24	95	36	155
Man	12	112	26	150
Woman	8	102	35	145
Total	44	309	97	450

The trend towards the greater participation of women in this area is closely related to the existence of an agricultural economy linked to smallholdings with a lower productivity; in many cases, this generates the need for the greater diversification of family economies. In addition, the existence of a large number of natural and cultural resources in this tourist area serves as a focus of attraction for travelers, and these are the key elements for the promotion and maintenance of accommodations.

In the study area, there is a significant representation of women in the management of tourist accommodations; however, in many cases, although a man is established as the owner, a woman is in charge of the management and development of the business. At this point, nowadays, female labor in rural areas is considered necessary to fix the population and generate new jobs, thus increasing the activity rates, and, in general, for the development of new economic activities that promote the process of productive diversification to effectively promote new development strategies in rural areas [53–55].

In terms of tourist demand, Valle del Jerte-La Vera received 121,403 travelers in the last year (2021), of which 90.7% (110,076) were nationals and 9.3% (11,328) internationals [56], with a homogeneous distribution, although with peaks at Easter (March–April) and in the summer months (June, July and August). Although with a lower volume of travelers, this trend follows the patterns of previous years, with the exception of 2020 due to the restrictions and effects of the pandemic crisis, which meant a decrease of more than 53% compared to 2019. Comparing the number of travelers that Valle del Jerte-La Vera receives with the rest of the tourist territories of Extremadura, over the last four years, it has established itself as the territory that receives the fourth-highest number of travelers, only surpassed by the main cities of the region, Cáceres, Mérida and Badajoz. Furthermore, in 2020, the territory under study received 9.6% of the total number of travelers in Extremadura, which reflects the fact that nature and rural destinations resisted, within their possibilities, the effects of the health crisis.

As can be seen in the following graph (Figure 12), the months with the lowest number of visitors coincide with the winter season (5.8%), while in spring (22.2%) and autumn (18.3%), they increase due to various factors, such as the good weather conditions and the presence of bank holidays or the Easter week, although the month with the highest number of visitors is August, with 23.1% of the annual total, which is why the period in which this territory receives the highest number of visitors is summer, reaching 53.7% in the last year. Thus, one of the problems in this area is the accentuated seasonality, where, in the summer months, the volume of visitors is 10 times higher than those received in January [36].

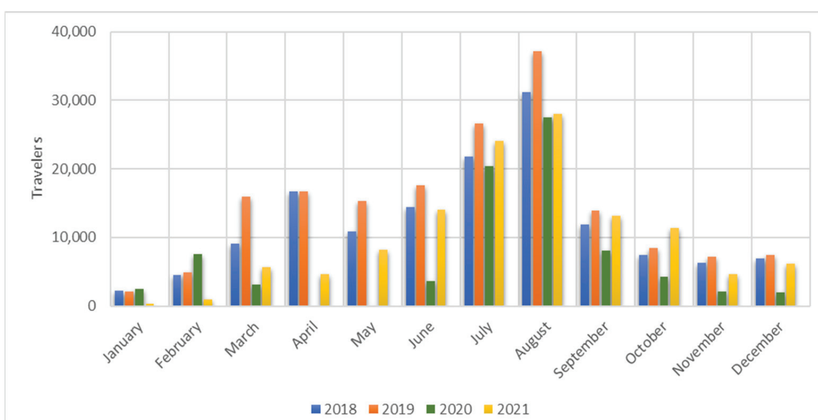

Figure 12. Graph of the evolution of total travelers during 2018, 2019, 2020 and 2021.

A more detailed analysis of the number of travelers shows a predominance of national travelers, who have accounted for over 90% of the total in the last four years. A homogeneous distribution pattern of national travelers is established throughout the year, with an upturn during the summer months, especially in August, when it reaches its peak. Mostly, this is due to the "paisano tourism", where people from the town who live in the cities return to the town during the summer vacations. In the years prior to the pandemic, there was a peak in the months of Easter (March–April) and the Cherry Blossom Festival.

Moreover, the distribution of international travelers does not follow the same pattern as that of national travelers, which is distributed irregularly throughout the year (Figure 13), finding that the maximum value of these travelers also occurs in the summer season (June, July and August). It should be noted that, analyzing the last four years, the maximum number of international travelers was reached in 2021, with values of over 2000 travelers.

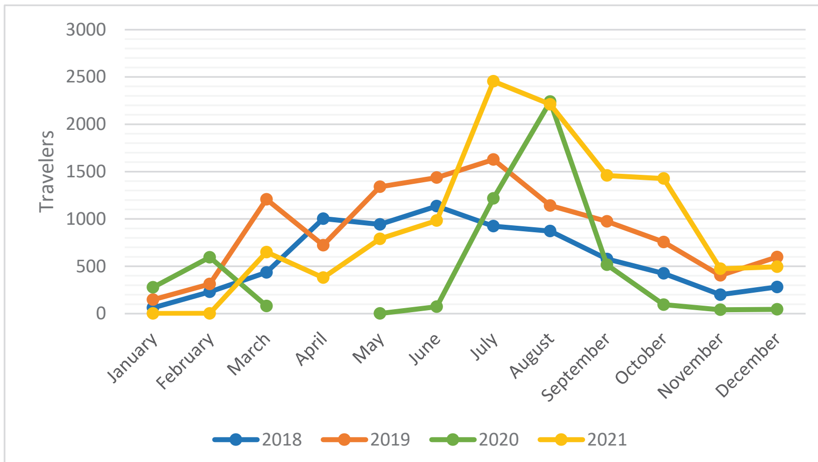

Figure 13. Graph of the evolution of international travelers for the years 2018, 2019, 2020 and 2021.

Analyzing travelers according to the accommodation in which they stay overnight, hotel establishments receive the most travelers (56,345 in 2019 and 24,602 in 2020), followed by rural accommodations (52,960 in 2019 and 22,395 in 2020) and campsites (42,523 in 2019 and 21,578 in 2020). There were lower values for tourist flats, which received almost 14,500 travelers in 2019 and slightly over 10,000 travelers during the pandemic. Finally, in the latter year, hostels did not even reach half of the number of travelers received in 2019.

In terms of overnight stays, these follow a similar pattern to the number of travelers. This is why the trend during the first two years of the study was an increase in these overnight stays, since the values increased from 368,348 overnight stays to 429,124, but, due to the crisis suffered, this trend was terminated. This is why, due to the reduction in the number of travelers, overnight stays experienced this decrease, which was even more accentuated as the values did not reach 218,000 overnight stays in 2020, a decrease of more than 49% with respect to 2019. It should be noted that in the last year, these overnight stays have been recovering, amounting to a total of 310,817 overnight stays in 2021. The upturn in overnight stays takes place in the summer months, with August being the month with the highest number of overnight stays. It should be noted that, in October last year, the number of overnight stays in 2018 and 2019 was exceeded, with an increase of more than 7000 overnight stays.

According to the distribution by the types of accommodations of these travelers in 2019, campsites are the establishments with the highest number of overnight stays in this tourist territory, with more than 132,000, while, in 2020, they did not reach 75,000 overnight stays. This was followed by rural accommodations, with 122,025 overnight stays, and hotel accommodations, with 117,556 overnight stays in 2019, a reduction of more than 50% in the year of the pandemic. Meanwhile, tourist flats received 37,000 overnight stays and hostels almost 20,000 overnight stays in 2019, values that dropped to 29,000 and 5600 overnight stays, respectively, in 2020.

4. Discussion and Conclusions

Extremadura is one of the communities with the highest increase in the rates of travelers and overnight stays, but these values are much lower than the national values. Bearing this in mind, the development of tourism is not the same in all the tourist areas of Extremadura, nor even between the northern areas of the region, due to the demographic, social and economic structures and the characteristics of each one. In this way, and according to this classification, there are territories with a high degree of tourist development in the cities of Cáceres, Mérida and Badajoz, followed by the study area, Valle del Jerte-La Vera. This area is characterized by a wide range of non-hotel and rural accommodations due to its great cultural, natural and scenic attractions. Furthermore, Valle del Jerte-La Vera has carried out an important tourist campaign, not only at a regional level, but also at national and even international levels, to establish an integrated offer combining its products par excellence, cherry and paprika, with its rich natural landscape and its gastronomy [40,57], which, together with its proximity to Madrid, has helped it to gain a foothold in both the national and international markets.

Based on the results obtained, it is verified that the demographic, economic and territorial characteristics are related to the development of tourism in various areas of the Extremadura region.

Firstly, and bearing in mind that the largest number of travelers and overnight stays in the region are concentrated in the cities of Cáceres, Mérida and Badajoz, focusing only on the tourist areas, Valle del Jerte and La Vera is the area that receives the most travelers, reaching more than 120,000 travelers last year, due to the impressive attraction of the Cherry Blossom show, in which visitors can admire the modeling of the terraces of the valley to adapt to the cultivation of cherries and the great mantle of white flowers that covers it, conveying the arrival of spring, where the PDO Jerte cherry will have special relevance and impact. Moreover, La Vera, similarly to Valle del Jerte, has numerous gorges and pylons that welcome travelers, especially in the summer months, as well as the local cuisine, which highlights the paprika PDO La Vera.

In both areas, rural tourism, agrotourism and nature tourism predominate, given the conditions of the area. In terms of distribution throughout the year, these travelers, who are mainly nationals, are established homogeneously throughout the year, with peaks at Easter and during the summer months, following the same pattern as the number of travelers to the region.

With regard to the supply, in terms of the number of accommodation establishments, the rural-type establishments stand out, with around 200 establishments, while the largest number of places available is concentrated in non-hotel accommodations, which has gradually increased to over 440 places at present, due to the proliferation of tourist flats in the area. It should be pointed out that, in their distribution by municipality, the county seats concentrate the greatest amount of accommodations and, likewise, practically all of the services available in this territory.

In relation to these variables, authors, such as Hernández-Mogollón, et al. [22] have established that visitors to this area of the region are predominantly hikers (86%), and they do not stay overnight in this territory; among the travelers who stay overnight in the area, it is mostly for a short period of time (one or two nights). With regard to the motivation for traveling, authors, such as Sánchez-Rivero et al. [36] state that the main reason for traveling to this area is the cultural visits, followed by rural tourism and river or gorge tourism. Moreover, in the analyses of other authors [42], the reason for such trips is the quality of the landscape (90.3%), the historical-artistic heritage (28.5%) or the quality of the typical products and gastronomy (22.6%). Furthermore, this type of tourist has been described as a person of mature age, with a medium-high level of purchasing power and with experience in tourism.

In this territory, tourism has become one of the activities with the greatest potential for endogenous development. Taking into account this influx of travelers and their seasonal nature, as mentioned above, numerous initiatives have been launched to promote and boost the area with cultural, gastronomic, leisure and sporting activities, and even popular festivals, such as the Cherry Blossom and Jarramplas festivals. In terms of gastronomy, different resources of the area have been promoted, many of them with the quality seal of Protected Designations of Origin (PDO), such as the cherry of Valle del Jerte and paprika from La Vera, through gastronomic events, tapas fairs, etc. In the case of leisure and sporting activities, Agorreta et al. [58] state that, in recent years, numerous companies have been set up, linked to active tourism activities, guided routes, routes linked to water, canoeing, 4×4, etc., such as the Garganta de los Infiernos Mountain Race in Jerte (in April) and the Picota Bike Race Cycling Marathon in Navaconcejo (in October), among others. All of this is due to the fact that accommodations and restaurants need activities to complement this tourist offer.

In recent years, this leisure offer has been increasing with professional, competitive and quality companies, largely linked to active nature tourism, so it is necessary to promote other segments that complement this tourism, such as health, relaxation, gastronomy, etc. Nowadays, tourism marketing determines the promotion of the destination, which is why it is necessary to plan the tourist offer in order to promote the image of the area, which increases its value and positions it as a destination that tends to be more in demand and competitive.

Several authors [59–61] have analyzed the evolution and influence of tourism strategies in rural areas of our country, establishing at first that rural tourism served as a complement to agricultural incomes [14,19,23,62], but subsequently, after the economic crisis, this activity began to develop as the main activity capable of generating profits in many areas of the interior of the peninsula, as has been the case in Valle del Jerte-La Vera.

Due to the territorial characteristics of the areas in which it is developed, rural tourism is currently considered a territorial strategy for its contribution to the creation of employment and, consequently, to the fixation of the local population, due to its capacity to generate complementary income and, furthermore, to be capable of generating support and consolidation for the rural environment [18,63]. In this way, the protected areas are being used as a tourist resource, and the activities developed around them are generating a series of benefits, since, in areas such as Valle del Jerte-La Vera, they receive a large number of travelers and overnight stays, due, above all, to their proximity to Madrid, which is the main source of rural tourism travelers in Extremadura. Accessibility to the Spanish capital is a territorial variable and a determining factor in rural tourism [64,65].

This research has served to determine how the different variables that make up a territory (for example, the types of accommodations, the supply of natural resources) complement the tourist offer and to know whether they are positively or negatively influencing the attraction of travelers. For these reasons, quality tourism should continue to be promoted, especially in those areas where tourism cannot yet be considered as an engine of development and can be established as an activity that generates complementary income to the traditional agricultural one. Moreover, it is necessary to have the involvement of the public administrations and the private sector in new investments in the sector and de-seasonalize the demand through the promotion of new and more experiential products that contribute to an increase in the stay and income. Moreover, marketing strategies must continue to be developed to boost and promote the area, so that destinations such as Valle del Jerte-La Vera, attract a greater number of visitors and position themselves as prime destinations. All of this must be supported through planned and organized projects, with the collaboration and cooperation between the regions to promote the territory. Additionally, in this case, the inhabitants of Valle del Jerte-La Vera must commit themselves to the maintenance and conservation of their heritage and resources, because these are the main incentives for most of the tourists of this territory, particularly, and of Extremadura, in general.

Finally, the impact of the COVID-19 pandemic has constituted a turning point in tourism activities and this must serve as a lesson for the future, so as to be able to anticipate other crises, in order to lessen their effects [66]. Its impact has varied depending on the territory in terms of its dependence on the tourism sector, the tourism model that it has developed and the traveler profile in which it has specialized [67]. This is why rural and mountain destinations, based on natural and cultural resources are benefiting from the increase in demand [68,69], as these territories can offer a product with the main characteristics in demand, related to low mass tourism, such as individual accommodations, open and wide spaces, territorial quality and services on offer. Even so, the tourism sector must be improved to ensure that this activity in the post-COVID-19 era is based on quality, innovation, sustainability and safety.

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Article

Protected Areas and Rural Depopulation in Spain: A Multi-Stakeholder Perceptual Study

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Abstract: Protected areas (PAs) are thought by some to contribute to local wellbeing and socioeconomic development, whereas for others PAs remain a regulatory burden that hampers rural development. Here, we sought to ascertain the perceived causes of rural depopulation and the potential impact of four Natura 2000 sites on the wellbeing and depopulation figures of four protected rural municipalities in Spain that were selected as extreme case studies. We used phone surveys to elicit experts' views (n = 19) on the topic and convened eight in-person workshops to garner local residents' insights (n = 40) using structured questionnaires. We complemented perceived wellbeing data from PAs with surveys to residents in neighbouring unprotected municipalities (n = 28). Both experts and workshops' attendees from protected municipalities overwhelmingly attributed depopulation figures to structural causes linked to transport accessibility, basic service provision and the existence of job opportunities, which they perceived to be unrelated to the PAs' regulations or management. Local residents did generally not perceive any impact on their collective or individual wellbeing from those PAs, and most who did, expressed a negative impact chiefly due to socioeconomic restrictions. Four-fifths of the experts and half of the workshops' attendees from protected municipalities, however, expressed that PAs' administrations could help improve depopulation figures in their towns mainly through promoting tourism and greater compatibility of land uses, including housing and infrastructure development. While the assessed Natura 2000 sites certainly have scope for tourism promotion, their lenient legal regimes make it largely unfeasible to broaden land use compatibility without damaging protected features.

Keywords: Natura 2000; impact; resident; expert; opinion; wellbeing; case study

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1. Introduction

The loss of rural populations entails a number of important social, economic and environmental changes for territorial sustainability. Among them, the cessation of traditional economic activities linked to the primary sector, ageing, the reduced provision of basic services, ecological succession leading to landscape changes, increased wildfire risk, the loss of cultural practices, or shifts in the provision of ecosystem services are all significant potential changes [1–4]. Rural depopulation has been affecting communities in developed countries for a long time [4–6]. More recently, it is affecting developing countries as well [1]. Rural depopulation has been a long-lasting issue in Spain. Massive rural emigration to cities and other European countries in pursuit of better working and living conditions took place in the country in the 1950s and 1960s. Such trends decreased in the following decades, but never stopped or were reversed [7,8]. After Spanish accession to the European Union in 1986, a number of policies whose main or ancillary objectives were to enhance the wellbeing of rural communities and stop rural depopulation have been implemented with European funds, notably through the European Agricultural Fund for Rural Development of the Common Agricultural Policy [9], although its implementation has been uneven in Spain [7,10,11].

Other policies of broad impact on the territory relate to environmental conservation. Protected areas (PAs) cover over 17.46% of the land territory of the European Union [12] and more than one-third of the Spanish land territory [13], and are expected to increase globally to cover at least 30% of land and sea areas by 2030 [14]. PAs may provide opportunities for rural development linked to enhanced ecosystem services and tourism [15]. PA regulatory and managerial regimes may, in turn, entail restrictions to some human uses of the territory that may diminish local wellbeing, exacerbate poverty and increase depopulation of rural areas [16]. A previous country-wide study found that protected rural municipalities in Spain had had generally worse depopulation trends than neighbouring unprotected municipalities, although exceptions occurred, mostly related to municipalities in Sites of Community Importance (SCIs), which tended to perform better than their controls [17]. Although the authors carefully controlled for a number of bio-physical covariates that might influence rural depopulation, they could not accurately attribute the depopulation effects to PA regulations given that other unconsidered factors might have influenced the fact that some municipalities performed better than others at maintaining or increasing their populations.

Stakeholders' perceptions on conservation initiatives, notably those of the people affected by environmental policies and regulations, allow researchers to delve into the causes and consequences of such initiatives, assess their social acceptance and estimate their success [18,19]. In this study, we used stakeholders' perceptions to refine the findings of the previous country-wide study [17] by: (1) Ascertaining whether PA regulations and/or management may have influenced depopulation in a sample of pairs of protected and unprotected small rural municipalities with the most contrasting depopulation figures in Spain; (2) Determining if other factors may have influenced depopulation trends in those municipalities; (3) Making recommendations to rural development authorities and PA authorities for enhancing the wellbeing of rural communities and reducing or preventing depopulation.

2. Materials and Methods

2.1. Research Questions

In this study we sought to delve into the causes and possible solutions to the depopulation issue in rural Spain through three research questions:

1. Have the regulations or managerial regimes of PAs affected local wellbeing and rural depopulation in the selected municipalities?
2. Are there other factors that may have influenced rural depopulation in the selected municipalities?
3. What can be done to improve depopulation trends in the selected municipalities?

2.2. Studied Municipalities

Four pairs of extreme cases regarding the values of three depopulation indicators from the initial census sample of 52 protected municipalities and 55 unprotected municipalities of the study by [17] were chosen. The original census sample of 107 rural municipalities from which those cases were taken had defined a 'rural municipality' as those municipalities that had less than 10,000 inhabitants [7] and were located further from 20km from cities of 10,000 inhabitants or more [20]. The 52 protected municipalities had over 99% of their territories inside a multiple-use PA, thus being affected by their regulations and management, whereas unprotected municipalities had less than 1% of their territory affected by PA regulations and management. Of our sample of four extreme pairs of municipalities in terms of contrasting depopulation figures, three pairs related to SCIs and one pair related to a Special Protection Area (SPA), which were first designated on each site. They had been designated between March of 1999 and January of 2001. Yearly municipal population data from 1996 until 2019 were retrieved from official sources [21], and three depopulation indicators were compared before and after the designation dates of each PA in case and control municipalities: Compound annual growth rate, proportion of reproductive individuals, and proportion of reproductive females (Table 1). Data were retrieved until 2019 due to the unusual data from 2020 due to the effects of the COVID-19 pandemic.

Table 1. Selected pairs of Spanish rural municipalities with the most contrasting depopulation figures before and after each protected area was designated in the 1996 – 2019 period. CAGR: Compound Annual Growth Rate; PRI: Proportion of reproductive individuals; PRF: Proportion of reproductive females. SCI: Site of Community Importance; SAC: Special Areas of Conservation; SPA: Special Protection Area.

Protected Area (Designation Date)	Protected Municipality			Unprotected Municipality		
	CAGR (%)	PRI (%)	PRF (%)	CAGR (%)	PRI (%)	PRF (%)
Hoces del Cabriel, Guadazaon y ojos de Moya (2001-SCI; 2016-SAC)	La Pesquera −1.43	−7.30	−17.66	Puebla del Salvador 0.22	2.02	5.14
Sabinares de Somosierra (2000-SCI; 2015-SAC)	Casla 0.43	12.44	17.93	Santa Marta del Cerro −2.26	−16.73	−10.05
Sierras de Urbión y Cebollera (1999-SCI; 2015-SAC)	La Poveda de Soria 1.97	1.67	16.11	Vizmanos −2.44	−13.86	−18.36
Penyagolosa (2000-SPA)	Chodos −1.77	−12.76	−27.69	Atzeneta del Maestrat 0.08	−1.35	−2.90

The four pairs of municipalities were located in four provinces belonging to three different Spanish regions: Castilla Leon, Castilla La Mancha and Valencia (Figure 1).

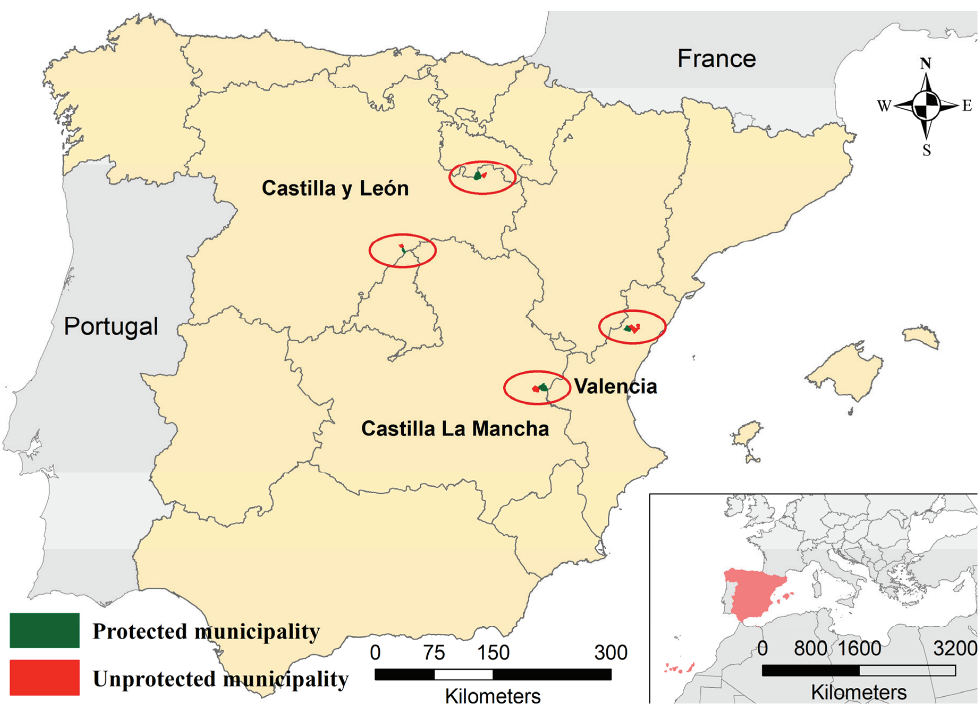

Figure 1. Location of the four pairs of municipalities in Spain.

2.3. Data Gathering

Two social groups, experts and local residents, were surveyed in protected municipalities in order to answer the research questions. Experts included town mayors, rural development officers from the provincial and regional administrations (provincial delegations), PA managers, and coordinators of rural development action groups. Rural development officers of the Valencia region could not be reached by phone despite numerous attempts. Local residents included 18 year-old and older people living in each of the protected and unprotected municipalities for most of the year or visiting them regularly outside main holiday periods for a number of years. Data from residents in unprotected municipalities were used to complement the results on the perceived impact of PAs on local wellbeing.

Two social science data compilation methods were used: (1) Experts were interviewed via telephone using a structured questionnaire (Annex S1); and (2) One workshop was held in each of the selected municipalities to garner the opinions of local residents using a similar structured questionnaire (Annex S2). A briefing explaining the background and objectives of the study was provided prior to each phone interview or workshop for context. Purposive samples of local residents were gathered in local councils' premises with the help of town mayors. COVID-19 prevention measures such as face masks and social distancing were taken at every workshop. A number of measures were taken to increase representation and participation of local residents. Firstly, guidance to increase representation of attendees to the workshops was sent to the mayors in advance via email (Annex S3). Based on such guidance, mayors were asked to identify potential attendees and invite them to attend the workshops. Moreover, a poster announcing the workshop was created for each of the municipalities and sent to mayors for greater dissemination of the event across the towns and broadened participation (Annex S4). All the workshops took place between 25 October and 4 November 2021.

3. Results

3.1. Sample Data

Nineteen experts responded to our phone interviews on the four protected rural municipalities (Table 2).

Table 2. Type of expert interviewed by phone on the protected municipalities.

Expert Type	Number
Protected area manager	4
Town mayor	4
County rural development coordinator	4
Provincial Government—Rural development officer	4
Regional Government—Rural development officer	3

Forty local inhabitants attended the workshops and filled in the questionnaires in the four protected municipalities. Fifty per cent of them were men and fifty per cent were women, and they ranged from 20 to 77 years old (mean age of 50.15 years). They had lived 28.8 years in town on average. Over half of them worked in the tertiary sector or were retired (Figure 2). Twenty-eight inhabitants from the four unprotected municipalities responded to the questionnaire. Fifty-seven per cent of them were men and 43% were women. Four questionnaires were rejected for having most fields or key fields incomplete or having been filled in by a neighbour from a different town.

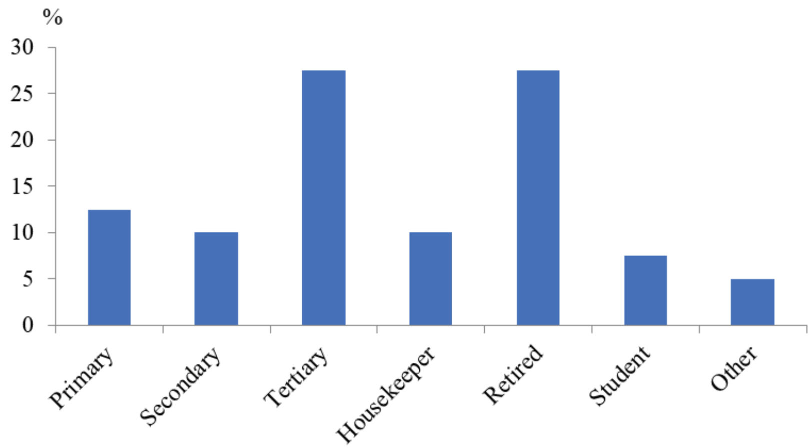

Figure 2. Occupations of respondents to the questionnaire in protected municipalities by sector, in percentage ($n = 40$).

3.2. *Effects of PAs on Rural Depopulation*

3.2.1. Experts

A total of 68.4% of the experts perceived little or no effect from PA regulations on depopulation of rural communities in PAs. A total of 21% of them perceived PAs to have had a positive impact against depopulation due to enhanced tourism activities and incoming subsidies, whereas 5% perceived negative impacts from PA designation. Half of the surveyed PA managers expressed that their Natura 2000 sites (one SCI and one SPA) had had no impact on depopulation, whereas the other two perceived negative or slightly negative impacts resulting from restrictions to economic activities.

A total of 68.4% of experts perceived no effect of PA management on rural depopulation, and 31.6% could not answer that question. All PA managers stated that PA management had not affected rural depopulation.

3.2.2. Local Populations

Ninety per cent of the workshops' attendees in the four protected municipalities stated that they perceived a trend towards depopulation in their municipalities prior to the COVID-19 pandemic in 2020. However, 70% of them stated that the PAs had had no impact on the residents' wellbeing. For 20% of the attendees, the PAs had had a negative impact on the towns' residents' wellbeing chiefly due to socioeconomic restrictions, whereas 7.5% expressed they had had a positive impact. A total of 80% of the attendees in protected municipalities perceived no impact of PAs on their own wellbeing, 15% stated a negative impact, and 5% expressed a positive impact.

Of the eight respondents perceiving negative collective impacts from PAs, three worked in the primary sector (farming or forestry), and two were retired. However, only half of them, including a pharmacy worker and a retired person, stated a negative impact of the PAs on their own wellbeing due to socioeconomic restrictions and complex administrative procedures. Of the three attendees stating positive collective impacts of PAs on the grounds of enjoying nature and rural conservation, one worked in the industry, one was disabled and the other was a cattle farmer. The farmer, however, stated negative personal impact from PAs due to restrictions to her activity.

Almost 93% of the workshops' attendees in unprotected municipalities expressed that the PAs' regulations had had no impact on the residents' wellbeing or on their own wellbeing. For 7.1% of them, PAs had had positive collective and individual impacts. One of the reasons for this was that PA regulations allowed for rubbish tips to deposit dead cattle.

3.3. Other Causes of Rural Depopulation

3.3.1. Experts

The main stated cause for the relatively good depopulation values in the two best performing protected municipalities was good transport infrastructure (Figure 3).

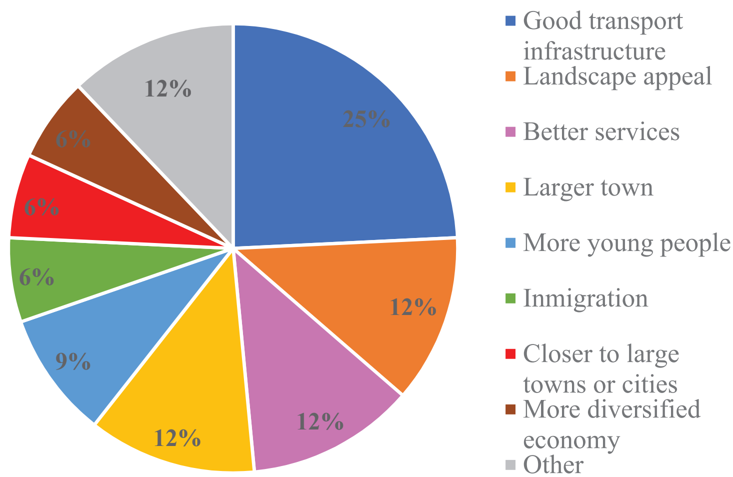

Figure 3. Stated causes for the depopulation figures in the two best performing protected municipalities, according to experts.

In contrast, a range of individual causes, including poor transport infrastructure, insufficient job opportunities and isolation were chiefly mentioned to explain the poorer depopulation values in the two worst performing protected municipalities (Figure 4).

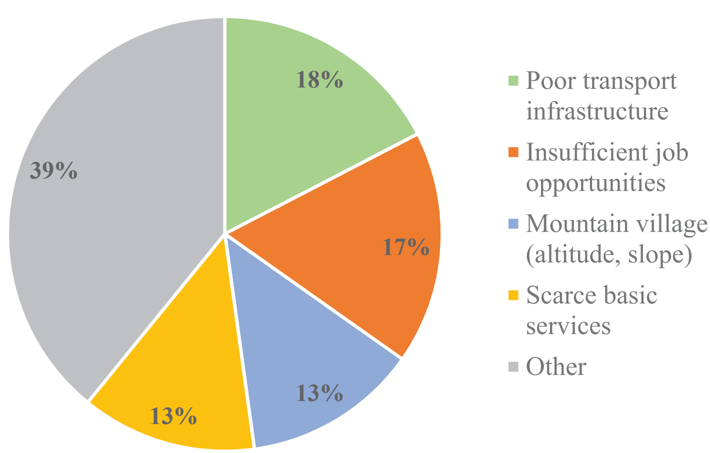

Figure 4. Stated causes for the depopulation figures in the two worst performing protected municipalities, according to experts.

3.3.2. Local Populations

All the workshops' attendees from protected municipalities mentioned some causes for the depopulation figures of their municipalities. Among them, the two major ones were 'Insufficient job opportunities' and 'Scarce basic services', accounting for 50% of all the stated causes (Table 3).

Table 3. Stated causes for the depopulation figures in protected municipalities, according to local residents.

Cause	Mentions (%)
Insufficient job opportunities	27.93
Scarce basic services (incl. Internet)	22.52
Transport infrastructure	8.11
Administrative issues	6.31
Housing availability	4.50
Absence of economic incentives	4.50
Closeness to larger towns or cities	3.60
Immigration	3.60
Few births	2.70
Youngsters remained	2.70
Scarce land availability	1.80
Emigration	1.80
Difference between official population figures and reality	1.80
Other	8.11

3.4. Recommendations to Revert Rural Depopulation

3.4.1. General recommendations

A total of 94.7% of the experts suggested some actions to improve depopulation figures in protected municipalities. The main proposed action by the experts was improving or providing basic services, including high-speed internet (Figure 5).

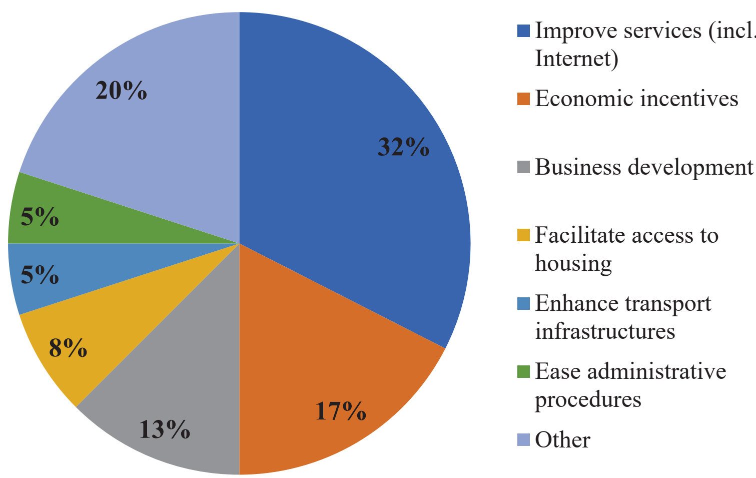

Figure 5. Experts' main recommendations to revert depopulation in protected municipalities.

All the attendees to the workshops provided some ideas to improve depopulation figures in their towns. Nearly three quarters of the proposals had to do with providing, improving or maintaining basic services, developing businesses, or creating or providing jobs in general terms (Figure 6).

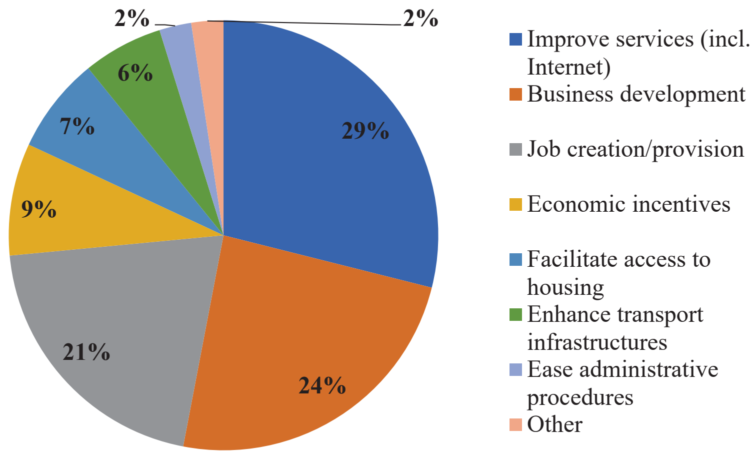

Figure 6. Residents' main recommendations to revert depopulation in protected municipalities.

3.4.2. Recommendations regarding Protected Areas

A total of 79% of the experts expressed that PA regulations or management could contribute to improving the municipalities' depopulation figures, chiefly through the greater compatibility of uses, promotion of economic activities and shared management of the sites (Figure 7).

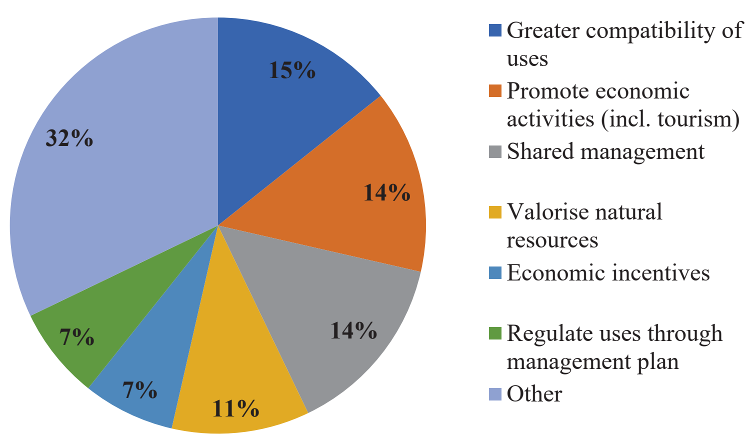

Figure 7. Experts' actions to improve depopulation figures in protected municipalities to be implemented by protected areas' administrations.

Half of the workshops' attendees from protected municipalities thought that the regulations or management of their PAs could contribute to improving depopulation figures in their municipalities, mainly through tourism promotion and easing restrictions to development (Figure 8).

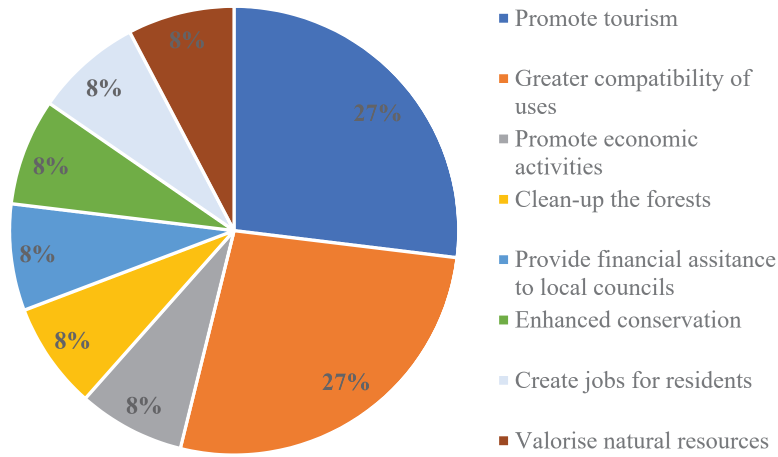

Figure 8. Residents' actions to improve depopulation figures in protected municipalities to be implemented by protected areas' administrations.

4. Discussion

4.1. Effects of PAs on Rural Depopulation

There was broad agreement between residents and experts that PAs had had little or no effect on rural wellbeing and depopulation. Some previous studies had shown little, if any, social or economic impacts at a municipality scale from PA designation on land [22,23] and at sea [24] in European settings. However, for a noticeable number of the workshops' attendees and PA managers, PA designation had had some negative impacts on local wellbeing and depopulation due to restrictions to economic activities. The authors of [25] found similarly negative social perceptions on Natura 2000 sites linked to socioeconomic restrictions and little social engagement in PA designation and management across Europe. These results also align with a previous study using official statistics in Spain where protected municipalities generally performed worse than unprotected ones when facing rural depopulation [17]. Our results, however, contrast with those based on perceptions on European PAs from [18]. In their review, they found mostly positive perceived effects of European PAs on wellbeing and local livelihoods, except for MPAs. In other settings, different authors found varying outcomes of PAs using semi-experimental research designs: [26] stated no demographic or socioeconomic differences between municipalities inside and outside national parks in Colombia, especially after the armed conflict in the country had ended. In turn, [15] found that PAs in Thailand and Costa Rica had improved the economic conditions of local communities, whereas [19] found that communities living closer to a PA in Kenya had experienced greater economic losses than distant communities, although non-statistical differences in welfare or poverty between the two were found.

In contrast to numerous claims [27–29], respondents from both protected and unprotected municipalities in our study did not mostly identify any specific benefits from ecosystem service provision by PAs. Previous studies suggest that the socioeconomic impacts of (M)PAs are mostly felt in rural communities in developing countries with a high dependence on natural resource exploitation [30–32], rather than in more economically diversified settings like Europe. As a result, many developing nations have established compensation schemes for local populations living near PAs to offset restrictions in access to natural resources and economic losses from wildlife [33]. In developed countries, a few specific socioeconomic groups linked to resource extraction, such as fishers, are likely to be the only ones noticeably affected by (M)PA regulations or management [18,34,35]. In our study, very few respondents perceived a positive impact of PAs on local depopulation and wellbeing linked to an increase in tourist activities or ecosystem service provision, as often suggested for PAs [27,36–38]. Only the most geographically detached participants in our study, including non-PA managers and residents from unprotected municipalities, perceived slightly positive impacts from PA designation overall. This is consistent with previous studies that showed worse perceptions of social and economic effects of PAs by local stakeholders [18,39]. Our sample of respondents were asked about leniently regulated, multiple-use Natura 2000 sites in which a broad range of socioeconomic activities are allowed and even encouraged [40]. Thus, normative restrictions are less likely to be felt in those sites compared to more stringently regulated reserves [41]. Nevertheless, the large numbers of variables that may affect social, economic and demographic variables at a local scale make it challenging to attribute socioeconomic outcomes exclusively to PAs, even if confounders are considered [26,42,43].

No impact of PA management on depopulation was perceived by any of the experts. Actually, the three SCIs were endowed with a management plan recently and became SACs between 2015 and 2016. Such plans include a number of management guidelines and actions to be implemented according to budgetary availability. However, few of those actions have seemingly been implemented yet. In turn, the SPA had no management plan and was not actively managed at the time this study was conducted. A substantial delay in the development of management plans for Natura 2000 sites in Spain meant that a notable number of such sites had not yet been endowed with a management plan by 2020 [44]. Actually, by the end of 2017, the reported overall status of management planning in Natura 2000 sites across Europe differed by country but was overly deficient [45].

Stakeholders' perceptions are considered essential to the assessment and eventual success of conservation initiatives [18,19]. However, they have been found not to always align with objective data [22,39,46]. Therefore, care should be taken when making decisions that are entirely based on perceptions; such decisions should ideally be complemented with reliable statistics.

4.2. Other Causes of Rural Depopulation

Three major themes affecting rural depopulation stood out for both experts and residents: transport infrastructure, scarcity of basic services, and insufficient job opportunities, as previously shown for many Eastern and Southern European rural areas [6,47]. The importance of transport networks for rural depopulation has been previously highlighted, with some successful alternatives to private transportation in rural areas being implemented [48]. All the surveyed municipalities (protected or unprotected) showing better depopulation figures after PA designations were connected by national or regional roads, whereas all the municipalities with worse depopulation figures at that time were accessed only by local roads, which complicate access to basic services that are not provided locally [47]. It is noteworthy that the two best-performing protected municipalities had national roads, which were developed before the PAs' designation. It is most likely that improvements in their accessibility would have been more challenging in those sites had the PAs been designated before such roads were made [49,50]. However, linkages between PA regulations and transport infrastructure development did not explicitly arise from the questionnaires.

The scarcity of basic services, including healthcare, primary and secondary education, public transport, food provision and cultural and leisure activities has been a constant claim by Spanish and European rural residents for a long time [6,7,47]. Shortages and little diversity of job offers, mostly linked to the primary sector, have also been a major well-known cause for rural depopulation in many European settings [6]. However, it is worth mentioning that some residents expressed both in the questionnaire and verbally that there were difficulties in finding workers for some physically demanding jobs in their towns, such as bartender or baker. Many of these jobs are covered by immigrant populations [51,52]. Linked to this, short-term, publicly subsidized jobs were thought by some to outcompete privately offered jobs in terms of working hours and salary, thus hampering inner business development. Some residents also mentioned the challenge of seasonality in agriculture-related jobs.

It is remarkable that 'administrative issues' related to excessive bureaucracy, such as long and complex procedures for getting licenses and permits, were the fourth major perceived cause of depopulation in the protected municipalities. It is likely that part of that bureaucracy is related to the presence of the PAs, as administrative procedures tend to be greater in number and harder for PAs [50], especially if overlapping PA categories exist [53]. However, a noticeable number of residents mentioned neglect of developing initiatives and projects by public administrations even inside the towns' urban areas, which also points to governance issues [47].

House availability was mentioned by both experts and residents as a moderate factor for depopulation. This is surprising in places with small or shrinking populations and ample land for development. Little new offers, the poor state of available houses, high prices and a reluctance to sell properties were mentioned as causes limiting house availability in a number of protected municipalities. Of all these causes, PAs are likely influencing new residential offers by restricting new developments, which may in turn contribute to rising prices, although this should happen in contexts of high housing demand, which did not seem to be present in any of the protected municipalities.

4.3. Recommendations against Depopulation

Experts and residents generally agreed that the main measures to improve depopulation figures related to basic service provision, business development and economic incentives. Basic service provision through re-opening, restoring or opening new facilities (including remotely provided services) in suitable developed areas should be compatible with PA management and conservation, and relies chiefly on political and economic decisions [47,54,55].

Given the economic inefficiency of having permanent services in every small town, some experts suggested a county-scale scattered provision of basic services so that all rural populations have access to all needed services (e.g. primary and secondary schools, general practitioners, daycare centres, supermarkets, public transport to bigger towns or cities, banking, culture, etc.) within a short distance of around 20km from their places of residence. The overall success of such arrangements is largely dependent on an efficient and frequent public transport system which grants effective access to local services to all residents [56]. A combination of virtual delivery of some services, home delivery of some other services and a diversified territory though a spatially limited network of basic physical services accessed through a sufficiently frequent public transport system seems a feasible compromise between social and economic sustainability for Spanish rural populations [7,47]. Moreover, rural areas should use existing and innovative approaches to valorise their large, varied and unique natural and cultural capitals as a source of endogenous development [47].

Immigration has been shown to reduce or even revert depopulation in some Spanish rural areas [5,57,58], although it is thought not to offset population losses in European rural areas [47]. Young immigrants often take up low-waged, physically demanding, unskilled jobs—some of them outside the formal economy—that many locals are unwilling to do [51], thus helping to maintain population numbers, services, landscapes, and rural traditions [5]. However, attracting foreign workers was not mentioned as a possible solution to depopulation issues either by residents or experts.

The main measures to improve depopulation figures to be taken by the PAs were linked to promoting tourism and greater compatibility between conservation actions and socioeconomic activities. Natura 2000 sites have been devised to be compatible with a broad range of socioeconomic activities [40]. Only impactful activities that may compromise the effective conservation of biodiversity are restricted or forbidden in them [49]. However, some such activities, such as housing or infrastructure development, were demanded by some of our respondents, including some experts, as measures to enhance population figures and rural wellbeing. Natura 2000 sites cover over 17% of the territory of the European Union and include the most valuable places for biodiversity in Europe [9].

Developing those sites can and should only happen exceptionally and should be offset by adequate compensatory measures [49]. Thus, developmental options cannot generally be regarded as feasible solutions for protected rural areas.

In contrast, tourism has been advocated as the great economic benefit from PAs to local communities [36,59,60], although benefit sharing issues are common, especially in developing settings [61]. Moreover, costs to local populations from tourism development such as rising prices or restricted access to land are often overlooked and should also be taken into account [62]. Tourism has actually proved to be beneficial for some protected communities around the world [27,32,37]. Nevertheless, tourism in Natura 2000 sites is still low given the little degree of knowledge of the network by European populations [63,64] and the scarce tourism infrastructure in place in many sites. Even where some visitors' infrastructure is in place, very little data exist on how it is used or how it influences visitors' awareness and behaviour [59]. Moreover, tourism in PAs needs to be carefully planned and managed so that visitors do not jeopardise conservation with their behaviours or numbers [65]. Thus, given that still a notable proportion of Natura 2000 sites in Spain have little or no active management yet [44], broadly promoting tourism in such sensitive areas might be risky from a sustainability viewpoint and should be handled with care.

Social restrictions and health issues linked to the COVID-19 pandemic have caused substantial urban-rural migration in Spain from 2020, leading to population recovery in many rural areas [66]. It is, however, uncertain whether such a trend will remain once the pandemic is controlled and the legal and health situations return to normal.

4.4. Methodological Remarks

There are some methodological considerations of this study to be made: firstly, the numerically limited nature of our samples of residents. We managed to survey 6.5% of the official census of residents in the four protected municipalities in 2019. There were, however, some claims by the interviewees that official populations registers are overestimated as some people in the register do not live in town for most of the year. Thus, our sampling percentage would likely be higher.

Factors such as the limited participatory tradition in Spanish rural municipalities, time coincidence with some agricultural works (seeding) and some weather events (some rain and haze happened just before two workshops) are likely to have reduced participation in the workshops [67]. Secondly, the samples of attendees to the workshops were selected with the help of towns' mayors. This is likely to have entailed some bias in the sample of residents towards local-council-related residents and views. The non-random selection of attendees to the workshops meant that the representation of their responses might be compromised and should not be assumed. Nevertheless, we had no other means of reaching local residents other than relying on the town mayors and their dissemination of workshop information.

5. Conclusions

The major perceived causes for the protected municipalities' population trends were not related to PA designation or management, but rather to structural causes linked to transport infrastructure, job provision and basic service delivery. Actually, PAs were perceived to play a minor role in terms of rural depopulation and local wellbeing in the selected small rural municipalities.

Some of the proposed measures to improve depopulation figures and rural wellbeing, notably basic service provision and new job opportunities, are generally compatible with biodiversity conservation in PAs, whereas other more 'developmental' measures are not and should be addressed with care, given the sensitive nature of protected biodiversity. Natura 2000 sites could help create new jobs linked to PA management or tourism, but they have little potential for greater compatibility of land uses that respects ecological integrity, given their lenient legal regimes.

Future work would benefit from contrasting stakeholders' perceptions with official statistics in order to obtain a more comprehensive, less biased picture of the depopulation issue in small rural municipalities such as the ones studied here.

Supplementary Materials: The following supporting information can be downloaded at: https://www.mdpi.com/article/10.3390/land11030384/s1, Annex S1. Experts' questionnaire, Annex S2. Residents' questionnaire, Annex S3. Guidance to mayors on workshops' participants, Annex S4. Poster announcing the workshop.

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Article

Stakeholders' Participation in Sustainable Tourism Planning for a Rural Region: Extremadura Case Study (Spain)

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Abstract: The objective of this research is to obtain and analyze discursive information on the problems and solutions of the tourism sector in an eminently rural region, such as Extremadura, based on the opinions of stakeholders, in order to incorporate them into the evaluation and tourism planning of the region. More specifically, on the situation of the sector, perceptions on profitability and return on investment, the problem of overnight stays, and coordination between tourism agents and training demands, in order to make a sustainable tourism sector in a rural region. The research starts from the following premise: for tourism to be sustainable, stakeholders must participate in the strategic decision-making process. This paper aims, on the one hand, to clarify sufficiently the state of the art regarding the validity of focus groups and their analysis as a research methodology, explaining how to address the main challenges implied by this technique by reviewing a selection of research works that we consider relevant in this field. On the other hand, an analysis of the tourism sector in Extremadura is carried out based on these group dynamics. The main result, after analyzing the discourse of six focus groups, is that the different opinions of their members reveal, despite everything, that the training of human capital in the tourism sector in rural environments is a pending issue.

Keywords: focus groups; interest groups; stakeholders; tourism; Extremadura

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1. Introduction

Focus groups, also known as "discussion groups" [1], spread to the field of social research, especially market research, in the 1950s. Until then, in the 1930s and 1940s, they had been used as a psychotherapeutic strategy. The work of R. Merton and M. Fiske, entitled *The Focused Interview* [2], is one of the first references in this field, and serves as a starting point for the use of these group dynamics in the sociological study of different problems [1].

Focus groups are currently considered the central practice of qualitative social research [3]. Their constitution is that of a small group, between five and nine people, in interaction, guided semi-directionally by a moderator. The dynamics, lasting about an hour and a half, are articulated as a device for interpersonal communication, for the production and analysis of the group's discourse. It is, therefore, a practice in more or less controlled conditions and subject to revision, and it is not a closed technique. Such a conversation, relatively spontaneous and open, is recorded and transcribed verbatim for sociological or socio-hermeneutic analysis [3]. It is important to consider that, depending on the participants in these sessions, what is sought is a certain confrontation of positions. Starting with minimal verbal stimuli, the moderator encourages discussion on a basic issue (mores, corporate images, products/brands, or, as in our case, local tourism policies). Discursive production may appear fragmentary, but it involves a coherent bundle of virtual discourses sometimes underlying them. Their systematization as elements of a symbolic universe aims at defining the social codification keys of dominant ideologies (or positions) [3]. In summary, focus groups are a qualitative research tool whose essential characteristic is the explicit use of group interaction to produce data and insights that would otherwise be less accessible [4,5]. It is, therefore, an artificially created relationship [6,7], which is based on the logic that only the consumer (the tourist) determines the meaning of a product or service [8]. In Weeden's opinion [6], focus groups, as a rich and valuable data collection method, can be excellent and provide the researcher with the perspective of a small segment of informants. They may reveal some issues that the researcher has not previously considered, such as the importance of critical timing in the configuration of opinions and future actions [6].

The methodology used in focus groups applied to the study of tourism has at least three implications. First, the approach goes beyond the reductionism of positivist (exclusively quantitative) methods, thus incorporating a holistic view of the tourism problem [9,10]. Second, the use of focus groups incorporates the results of the interaction between the researcher and the researched. Consequently, it is accepted that the interaction, elucidated from the assessment of the actors involved in tourism, influences changes in the perception of tourism-related phenomena [11,12]. Third, this highlights the convenience of adopting a methodologically eclectic position in tourism studies, integrating qualitative and quantitative aspects of research.

This means that researching the tourism phenomenon allows for the adoption of an adequate perspective for the development of inductive logic, which, as is known, starts with specific, concrete observations and builds general patterns so that the approach to the understanding of a social phenomenon is basically speculative and exploratory [13]. This is the logic underlying tourism research that uses focus groups as one of the basic tools for understanding the reality of tourism [14,15].

Qualitative research focuses on observing people in habitual, everyday settings to understand and interpret how they maintain their social worlds. Hardy's [16] ontological assumption was that people, with their differences, perceive events in different ways [17,18]. Therefore, the goal is to understand how people perceive the world, the reasoning behind their actions, and to provide a deep understanding of social environments [15]. From this, the epistemological approach of this study assumes that values are inherent to human beings. Therefore, research cannot be value free. Research is subjective, as a result of the interaction between two people: the researcher and the respondent [17]. Consequently, it is assumed that perceptions of "reality", as understood by the respondent, would be formed by the researcher [12,19].

As part of the methodological logic of qualitative research, the data provided by the focus groups are not intended to be statistically representative [7]. However, focus groups are an appropriate tool to discover the perceptions and perspectives on a wide variety of tourism-related aspects, as they provide a broad understanding of the way of thinking, beliefs, and attitudes of both tourists and the social actors involved in this sector of activity [20,21].

This work is the result of research that uses focus groups to learn the perspective of stakeholders (agents or interested parties) in tourism. For this purpose, six group dynamics were carried out in different locations in Extremadura (Spain). The qualitative perspective adopted in this work consists of using an exploratory approach, focused on a small number of people and/or cases (although sufficiently significant), which are usually studied to determine the meaning of social problems generalizable to large populations, and for a genuine understanding of information [22–24].

We consider that the main contribution of this article is to gather significant references in the field of the study of tourism, based on qualitative techniques, such as focus groups, to analyze these references in order to try to find elements of connection and coherent articulation with a view to their application to the specific case of the evaluation of regional tourism policies, such as the study of the assessments and perceptions of tourism development held by stakeholders in a peripheral region of southern Europe.

This article arises in a context in which political leaders and professionals in the tourism sector tend to take into account only quantitative data on tourism supply and demand when analyzing the situation of the sector. This work aims to highlight the fact that statistical analyses must be complemented by the discursive contribution, duly treated and processed, of significant leaders in the sector. Reflection on the local and regional tourism reality can be understood in a more complete way if the stakeholders' contributions are taken into consideration. The analysis and interpretation of the reality of tourism should not be limited exclusively to statistical and quantitative research but should be complemented by the analysis of the stakeholders' discourse through research methodologies and analysis by means of focus groups. With these group dynamics it is possible to involve the essential actors of the sector, improving the interpretation of the data and making possible a more realistic planning of future strategies for the development of the sector.

Table 1, based on a deductive approach, shows the stages of this process. Sánchez-Hernández, Robina-Ramírez, and De Clercq [25] explain that the application of deductive categories works on the basis of a prior theoretical definition of the main aspects of the analysis, which connects them with the texts.

Table 1. Deductive model applied.

Stages	
(1) Objectives: Research Proposals	
(2) Definition based on theory: Main categories—Subcategories	
(3) Codebook	3.1. Formative reliability check
(4) Working through reports (code merging)	4.1. Summative reliability check
(5) Interpretation of the results	
Discussion/Conclusions	

Source: own elaboration based on Sánchez-Hernández, Robina-Ramírez, and De Clercq [25].

The collection of codes in a coding diary is the way to verify reliability (formative checking). Making categories and code definitions explicit is an important part of the analytical process, as elucidated by Bernard, H.R. and Ryan, G.W. [26]. Subsequently, the transcribed texts of the audio recordings of the focus groups are analyzed by assigning codes that, in turn, may generate new codes, which are to be merged, and if necessary, accepted and integrated into the coding agenda, being considered as another result of the research and an adaptation of previous theory to real case studies. According to Sánchez-Hernández, Robina-Ramírez, and De Clercq [25], text coding could be interpreted as a "summative check" of reliability. Therefore, after the first round of work on the transcripts, we focused on the main categories and subcategories. Finally, we reached the point where a repetition of codes occurs and theoretical saturation is reached.

2. Literature Review

Focus groups, understood as individuals having a discussion on a delimited set of topics and expressing their attitudes and opinions interactively, have been widely used as a form of qualitative research analysis [15]. By using them, researchers can obtain a better idea of the design of pre-questions and conceptual explanations for a given target group of customers–tourists [27].

Pearce and Gretzel [28], in line with the work of Jacobsen [11], introduce into the qualitative perspective the emic–etic disjunctive. In their view, what underpins focus group studies is the emic approach, a perspective that is consistent with recent concerns in social science research about the relationship with the evaluation of human responses to social problems. As Rossite [29] suggests, researchers have been too preoccupied with the reliability of their instruments and testing the validity of their tools by statistical indices, such as Cronbach's alpha, thinking that their measures are, therefore, sound. In the world of psychometrics, this is an incorrect view, since the tools of such summary statistics only report on the internal consistency of what has been measured, but not on the fundamental validity of the phenomenon under study. The views of Rossiter [29], are similar to those of Gomm [30], Pisani [31], Flick [32], and other authors who are specialized in ensuring that a phenomenon is well understood from the way we collect information, and who are consistent with the use of an emic approach as a first step to exploring reactions to new topics, such as tourist experiences, in areas without internet coverage ("dead zone"). This is the focus of the work we will discuss, which is based on the qualitative perspective. Pearce and Gretzel's [28] working procedure consists of selecting components for a total of five focus groups to investigate the experiential dimensions of being in dead zones. As suggested by these authors, the literature provides evidence that exploratory work in the field of tourism is particularly consistent with this emic approach, in which the issues that are important to the participants are key to the research [33]. The emic approach prevents researchers from prejudging problems that directly affect participants, as researchers' impressions can be misleading and fail to capture all components of interest, when their use of scales and structured response measures is indiscriminate to new research problems [29].

Qualitative research involves using a series of carefully designed controls and strategies to maximize the value of the approach [34]. These components include paying careful attention to participant recruitment, facilitator consistency, and a well-organized procedure to ensure the quality of information to be obtained, as implemented by Pearce and Gretzel [28] in their work on the experience of tourists in technologically "dead" zones.

One of the main problems presented by qualitative research is that of data validity. Angen [35] suggests that, within interpretive research, validation is "a judgment of the trustworthiness of an investigation". Qualitative research is often criticized for losing the principles of "good science". There are two reasons for this: positivism remains the predominant paradigm in many areas of tourism research. On the other hand, qualitative researchers often fail to explain the soundness of their methods. This leads to confusion and misunderstandings. Decrop [36] lists the basic criteria for assessing the reliability of a qualitative study, and proposes triangulation as a way to implement them. Triangulation consists of strengthening qualitative findings by showing that several independent sources converge on them, or at least do not oppose them. Decrop [36] describes and illustrates, with examples from tourism, Denzin and Lincoln's [37] four basic types of triangulation: data triangulation, method triangulation, researcher triangulation, and theoretical triangulation.

Another way to validate the data obtained through focus groups is detailed description through a precise documentation of the field of study. This is the case of Zhang Qiu S. et al. [13], who describe, in detail, the experiences, setting, and personal characteristics of the fieldwork, so that readers can determine whether the findings can be transferred to other settings due to shared characteristics [24].

All of the above has led some authors to speak of a "New Tourism Research". Tribe [38] justifies this expression in a series of works that explore, from different perspectives, the territory of tourism research. Tribe draws a line between research that is mainly confirmatory and reproductive, and that which seeks to re-conceptualize. The aim is to highlight new ways of looking at the tourism phenomenon, based on a wide range of studies that go beyond the narrow limits of applied business marketing. For this author, this is a sign of the growing maturity of research in this field. According to Tribe, a growing body of authors is adopting a reflexive stance following the example of Botterill [39], for whom reflexivity means looking and reflecting on themselves as researchers, and outwardly on those they "research".

Stakeholder participation in tourism planning and development can take place in a variety of ways: public hearings, advisory committees, surveys, focus groups, public deliberation, citizen review panels, civic review boards, working groups, implementation studies, and written comments. In any case, what is clear is that stakeholders must be part of the tourism planning and evaluation process [40–42].

The review of previous works has already shown that focus groups are a good tool for activating stakeholders, in order to explore the relationship between stakeholders and perceptions of change induced by tourism, in the context of sustainability objectives of the tourism business, as in the case of Hardy [16]. At the methodological level, Guba [17] considers two aspects: hermeneutics, where individual constructs are represented as accurately as possible; and dialectics, where constructs are compared and contrasted.

In essence, it is interesting to note that the information obtained by Hardy [16] through these qualitative strategies is classified into 14 types, which are grouped into four thematic axes: (1) the tourism product, (2) impacts, (3) planning for the present and future, and (4) the ghost community. In a way, these four dimensions correspond to the thematic axes considered by Carter [43], including what he describes as the "ghost population" (which we could assimilate to the floating population of many villages in Extremadura); the tourist guests and tourism organizations (tourism activity and planning for the present and future); and the nature environment (impacts).

Tourist needs are changing and competition between destinations is growing. Tourism participation, innovative partnership, and the relationship between guests and hosts is essential, and this is possible by implementing these group dynamics with stakeholders to identify attitudes, values, and feelings, in the development of the tourism destination, as proposed by Lindroth, Ritalahti, and Soisalon [21]. These researchers, as a sampling method, opted for the "snowball" technique, albeit introducing some biases in the selection of participants. For example, the moderators chose to exclude active stakeholders and involve artists, for example. The reason for these variations in the selection of participants was the need to listen to new voices and ideas indirectly involved in tourism, and to avoid having conflicts between public and private sector representatives. Lindroth, Ritalahti, and Soisalon [21] conducted five focus groups between March and June 2006. The number of participants ranged from five to twenty components. The sessions lasted two to three hours and were recorded and transcribed. The data were analyzed using constant comparative analysis, which can be considered as a general approach in qualitative analytical strategies, originally developed for use in Glaser and Strauss' "grounded theory methodology" [44]. In this case, the main results of the focus group discussions were the socio-physical environment of the destination, service structure, consumer behavior, information and communication technologies, traffic, logistics and accessibility, networks, tourism demand and supply, local resources, and marketing and public relations.

In conclusion, we can say that focus groups can be especially useful to verify tentative considerations, as shown by Morgan [45]. Zhang Qiu Set et al. [13] use these dynamics to promote the expression of the participants' points of view, creating a suitable environment to encourage discussion and different opinions and points of view. The researchers identify trends in the perceptions and opinions expressed through systematic analysis as pointed out by Gutiérrez Brito [7] and Krueger, R.A. and Casey, M.A. [46]. In this work by Zhang Qiu Set et al. [13], all the qualitative data (the discourse expressed by the focus group participants) were processed in the NVIVO tool, which allows us to qualify and clean the data, and to highlight significant statements, sentences, or quotations. Open coding is performed first to identify factors related to the study. The team of Zhang Qiu Set et al. [13] took special interest in the triangulation and validation of the data provided by the focus groups. In this study, a variety of methodological combinations (participant observation, interviews, document analysis and focus groups) were used for this purpose.

3. Materials and Methods

Based on the preceding explanations of the state of the question, this section identifies the research proposals, their meaning, and the authors who support them. Additionally, an analytical tree is constructed, which denotes the relationship between themes, categories, and subcategories.

3.1. Methodology and Study Area

In this paper, we used discourse analysis applied to six focus groups formed by stakeholders of the tourism sector in Extremadura, using the discourse analysis software ATLAS.ti. This analysis is based on qualitative research, since focus groups have been used as a means to study the role and opinions of stakeholders when it comes to planning and evaluating the sustainability of tourism in an area or region, as Hardy and Pearson have already shown [16].

The process of working with "ATLAS.ti" consists, basically, in classifying each sentence uttered by the participants in the focus groups with a "label" or "key word". This classification system is used to simulate the quantification of the discourse.

The research starts from the following premise: for tourism to be sustainable, stakeholders must be involved in the strategic decision-making process. However, who are the real stakeholders in tourism development? Additionally, how should planners and developers involve these stakeholders in the tourism development process in a given area? Erick T. Byrd [47] asserts that, in the definitions used for sustainability and sustainable tourism, four types of stakeholders are identified: current visitors, future visitors, the current host community, and the future host community.

The following research work focuses on the opinions of tourism stakeholders in Extremadura. For this purpose, six group dynamics were organized in different urban/rural centers of the region. Extremadura (see Figure 1) is a region of just over 1.1 million inhabitants, representing 2.3% of the population of Spain, with a population density of 26.4 inhabitants/km^2. The low weight of the population of Extremadura in the national total of Spain and its weak occupation of the territory are the essential characteristics of the demographic structure. According to the Statistics Unit of the Directorate General of Tourism of the Government of Extremadura [48], 1,866,168 travelers visited the region in 2018. More than 80% of these visitors to Extremadura were of national origin (Spanish), and the remaining 17% were foreigners. Together, they accounted for 1.43% of tourists from Spain. In terms of the number of travelers it receives, Extremadura ranks 14th in the ranking of the 17 autonomous regions.

The objective of the focus group research is to obtain discursive information on the problems and solutions of the regional tourism sector [7] from stakeholders in order to incorporate them into the evaluation and tourism planning of the region.

More specifically, the aim is to capture the "discourse" of stakeholders on the situation of the sector, perceptions on the profitability and return on investments made in the sector, the problem of the increase in overnight stays, the coordination of tourism agents, and the demands for training [16].

In order to investigate the concrete formulation of evaluations and proposals for solutions that stakeholders propose for the tourism sector in the region, we have started from the formulation of questions to be discussed in propositional methodological terms, based on the literature presented briefly in the previous sections [25]. Table 1 shows the deductive model applied for data analysis. The stages that referred to the "reliability check" (3.1 and 4.1) are presented in a very synthetic form in the "discussion" section, in order to avoid digressions parallel to the central line of this work. This reliability check, in essence, is based on the triangulation proposals of Zhang Qiu et al. [13], Creswell [24], and Patton [23], which, in our case, are semi-directive surveys for entrepreneurs and tourism managers, and are standardized surveys to a broad sample (6106 surveys) to tourists—both of which were carried out in the same period as the focus groups developed in this paper; that is, in the last semester of 2018 [49].

The following are the research propositions that guide this inquiry into the discursive expressions of the six focus groups.

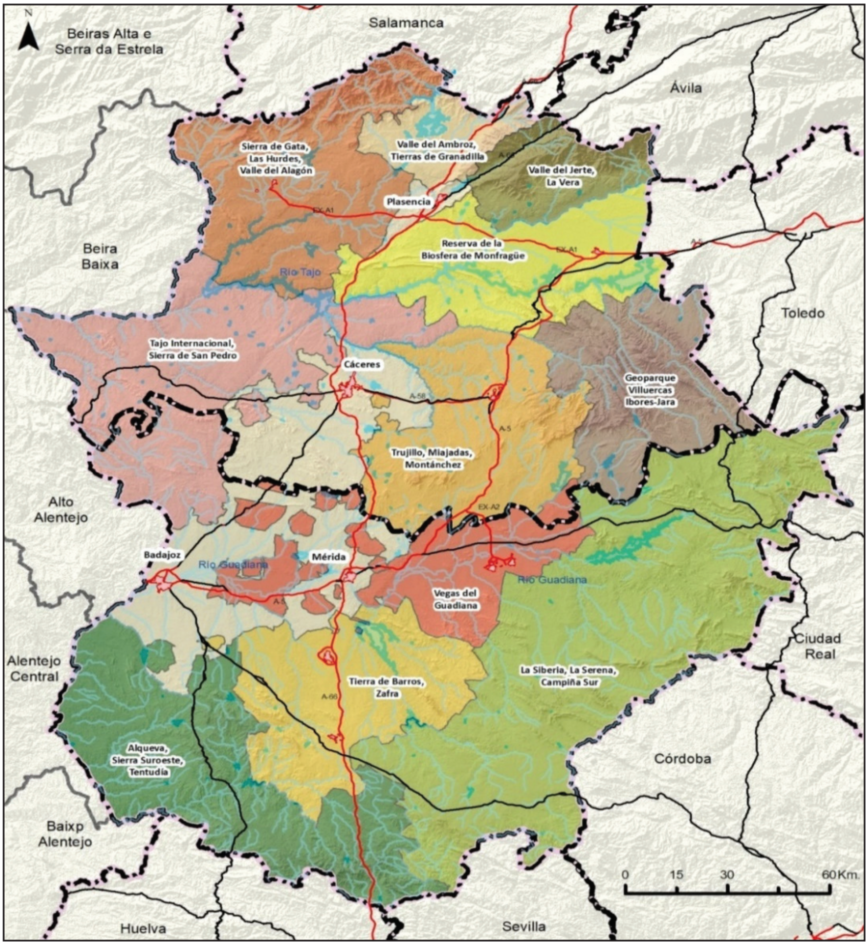

Figure 1. Tourist areas of Extremadura (Spain). Source: Tourism Observatory of Extremadura, Quarterly bulletin of tourism supply and demand in Extremadura Fourth-Quarter 2018 Document (14/2018). p. 78. https://www.viajarporextremadura.com/cubic/ap/cubic.php/doc/Guia-de-Extremadura-11.htm, accessed on 10 April 2021.

3.2. Research Proposals

In qualitative research, research problems can be posed in the form of propositions and questions to guide the inquiry. As King, Keohane, and Verba [50] point out that, ideally, all qualitative social science research projects should meet two conditions. Firstly, the research should ask questions that are relevant to the real world. Secondly, the research should contribute something concrete, "enhancing the collective capacity to provide scientific explanations for some aspect of the world" [50]. Our criteria for formulating the following research proposals explicitly mean that our work is situated within the framework of the existing scientific literature.

Proposition 1. *Current situation of tourism in Extremadura. What are the stakeholders' perceptions of the evolution of the sector in terms of economic growth and social transformation? This evaluation of the sector includes the state of institutional relations between agents involved in tourism (Tribe [38]; Hardy [16]; Wilson, Fesenmaier, Fesenm, and Van Es [51]; González-Herrera and Álvarez-Hernández [52]).*

Proposition 2. *Profitability and employment. Among the results required of the tourism sector in a region with high levels of unemployment, the need for tourism policies to have a social return that has an impact on tourism companies and employment stands out [16]. In this section, the aim is to collect contributions regarding opinions on institutional support for the sector and how the tourism labor market is perceived, a priori, characterized by job insecurity and low qualification of both employees and employers (Wilson, Fesenmaier, Fesenm, and Van Es [51]).*

Proposition 3. *The evolution of the tourism business is evaluated on the basis of "bookings, sales, and prices". How is this evolution perceived? What aspects favor or hinder inter-institutional coordination? How does this affect the tourism business? (Hardy [16]; Lindroth, Ritalahti, and Soisalon [21]).*

Proposition 4. *Typology of tourism. In such an extensive and diverse region, there are specific types of tourism (agritourism, events, cultural and historical tourism, and nature tourism) that need to be promoted in the different tourist areas, while other areas need to regulate their carrying capacity in order to make tourism activity sustainable without generating rejection among the population (Strielkowski, Riganti, and Wang [15]; Jacobsen [11]).*

Proposition 5. *Overnight stays. The increase in overnight stays is an essential indicator for the profitability of tourism investments and, to a certain extent, a legitimizer of public intervention in this sector. What can be done to increase the number of overnight stays by tourists visiting the region? (Hardy [16]; Wilson, Fesenmaier, Fesenm, and Van Es [51]; Lindroth, Ritalahti, and Soisalon [21]; Martínez Quintana and Blanco Gregory [53]).*

Proposition 6. *The role of tourism stakeholders (interest groups, administration, tourism professionals) is relevant for the evolution of the tourism sector; cooperation among them has an impact on the positive image of the sector and the region. In addition, it allows them to obtain a strong negotiating position vis-à-vis other authorities and sectors, with a view to future regulations and resource allocation (González-Herrera and Álvarez-Hernández [52]; Strielkowski, Riganti, and Wang [15]; Behringer, Buerki and Fuhrer [54]; Buhalis and Michopoulou [55]).*

Proposition 7. *Tourism promotion is a growing demand in the sector due to the increasing competition from other inland tourism markets. What ideas can be implemented to improve this promotion and support for it? (González-Herrera and Álvarez-Hernández [52]; Buhalis and Michopoulou [55]; Martínez Quintana and Blanco Gregory [53]).*

Proposition 8. *Specific training in tourism is one of the region's main challenges. It is considered that this factor can determine the evolution of the sector in two ways: in the improvement of supply and in the image of the jobs it generates, traditionally associated with precariousness and low salaries. Training goes hand in hand with training for entrepreneurship in the field of tourism (Wilson, Fesenmaier, Fesenm, and Van Es [51]; Behringer, Buerki and Fuhrer [54]; Hughes [56]).*

The result of these propositions–questions is a large number of individual codes that we have grouped into analysis categories for processing in the ATLAS.ti tool, which evidently maintain associations among themselves. Figure 4 shows the final coding "agenda" developed for this study, which seeks, following Sánchez-Hernández, Robina-Ramírez, and De Clercq [25], to ensure both formative and summative verification of reliability (Figure 1). The interpretation of the results is presented in the form of concept maps (Figure 4). Cáceres' focus group makes possible the presentation of the research results and is the basis for the discussion and conclusions of our work (Santana Leitner [57], p. 135).

4. Research Implementation

The focus groups used as a basis for this research were formed following the criteria of heterogeneity and saturation proposed by authors such as Gutiérrez Brito [7] and

Ortí [1]. Territorially, they were carried out in localities of the region, belonging to the urban (Cáceres, Mérida, Plasencia, Badajoz) and rural areas (Zafra and Guadalupe).

The discourse collected as a result of the focus group dynamics is part of and complementary to the contribution made by businesspeople and technicians through semi-directive interviews and standardized surveys (Sánchez-Oro Sánchez, Nieto Masot, Fernández Portillo, García García, and Cárdenas Alonso [49]).

The fieldwork was conducted from 17 to 30 October 2018, and the participants were relevant informants from the business sector and tourism technicians at the local and regional level, which we can typify as stakeholders (environmental and consumer associations, academics/scientists, entrepreneurs, managers of the chamber of commerce and industry, tourism business association, and trade unions) (Erick T. Byrd [47]; González-Herrera and Álvarez-Hernández [52]).

Speech processing was carried out with ATLAS.ti. Table 2 identifies the numbers of people summoned and those who actually attended the six sessions. The non-attendance rate (convened vs. actual attendees) is 45%, in line with works, such as those by Behringer, Buerki, and Fuhrer [54], Taylor and Prideaux [58,59], and other similar works.

Table 2. Persons invited and attending the focus groups in Extremadura.

	Invited	Attending	Entrepreneurs	Technicians	Duration
FG_CÁCERES	14	9	4	5	130′
FG_MÉRIDA	14	5	1	4	85′
FG_PLASENCIA	14	7	3	4	115′
FG_BADAJOZ	14	6	1	5	120′
FG_ZAFRA	14	6	4	2	120′
FG_GUADALUPE	14	5	2	3	80′
Total	84	38	15	23	

Source: own elaboration.

In essence, the problems dealt with in the focus groups revolved around the thematic axes described in the code table (Table 3), which are the situations of the sectors. Although the moderator starts from the assessment of the situation in Extremadura, the groups quickly descend to their more concrete and daily reality: profitability and employment; reservations and sales; the types of tourism according to the greater or lesser impact they have on their territories; entrepreneurship in tourism; the return on investments made in the sector; the problem of how to increase overnight stays; the coordination of tourism policies; as well as whether the private actor is involved in the design of public policies and the training of tourism professionals. Figure 2 shows the weight, in absolute values, of each discussion axis, based on the mentions made by the groups as a whole. Table 4, on the other hand, presents the data according to each specific group.

Table 3. Categories and codes. Reference authors of the research propositions.

Categories and Codes of Propositions [1]	Definition	Authors
Proposition 1. Current situation of tourism in Extremadura		
1.1. Higher growth	General economic outlook for the sector in relation to economic growth.	Tribe [38], Hardy [16], Wilson, Fesenmaier, Fesenm, and Van Es [51], González-Herrera and Álvarez-Hernández [52]
1.2. Coordination and institutional support	Assessment of institutional relations between companies and the administration, according to each tourist area.	

Table 3. *Cont.*

Categories and Codes of Propositions [1]	Definition	Authors
Proposition 2. Profitability and employment		
2.1. Employment status	Referred to the working conditions of employees, which include, in general, deficient qualifications.	Hardy [16]
2.2. Institutional support	Referred to the sources of financing and subsidies for business initiatives within this tourism sector.	Wilson, Fesenmaier, Fesenm, and Van Es [51]
Proposition 3. Evolution of the tourism business		
3.1. Bookings, sales, and prices	Stakeholders' perception of profitability in terms of "bookings, sales, and prices".	Hardy [16], Lindroth, Ritalahti, and Soisalon [21], Aichholzer [58]
3.2. Return on investment	Return on investments made in the sector	
3.3. Companies	Creation of companies and entrepreneurship initiatives in the tourism sector.	
Proposition 4. Typology of tourism		
4.1. Types to be enhanced	In certain tourist areas, there are types of tourism that should be promoted (Agrotourism, Hunting, Astrotourism etc.).	Strielkowski, Riganti, and Wang [15]
4.2. Types to be regulated	There are areas that show high levels of tourist saturation that can cause rejection by the population.	Jacobsen [11]
Proposition 5. Overnight stays		
5.1. Increase in overnight stays	It is understood that an increase in overnight stays is an indicator of a favorable evolution of the tourism business.	Hardy [16], Wilson, Fesenmaier, Fesenm, and Van Es [51], Lindroth, Ritalahti, and Soisalon [21], Martinez Quintana and Blanco Gregory [53]
5.1. Overnight stays down	It is understood that a decrease in overnight stays is an indicator of an unfavorable evolution of the tourism business.	
Proposition 6. The role of tourism stakeholders		
6.1. Integrated and coordinated sector	Generates solid negotiating positions in future regulations and resource allocation. Promotes a good brand and regional reputation.	Strielkowski, Riganti, and Wang [15], González-Herrera and Álvarez-Hernández [52], Behringer, Buerki and Fuhrer [54]
6.2. Disintegrated and competing sector	Weakens negotiating positions in future regulations and resource allocation. General reputational damage to the brand and the region.	Buhalis and Michopoulou [55]
Proposition 7. Tourism promotion		
7.1. The role of institutions and the role of companies	The positioning of the region in a complex market requires investments in promotion.	González-Herrera and Álvarez-Hernández [52]
7.2. The problem of communications (train and airplane)	Investment in promotion may be conditioned by infrastructure problems that make the destination attractive but inaccessible.	Buhalis and Michopoulou [55], Martinez Quintana and Blanco Gregory [53]
Proposition 8. Specific training		
8.1. Improving qualification	Specific training that has an impact on the quality of services rendered.	Behringer, Buerki and Fuhrer [54], Hughes [56]
8.2. Entrepreneurship	Training for tourism entrepreneurship.	Wilson, Fesenmaier, Fesenm and Van Es [51]

Source: own elaboration, based on Sánchez-Hernández, Robina-Ramírez and De Clercq. [25]. [1] These synthetic "power ideas" can also be referred to as "labels", which are common in Atlas.ti text processing.

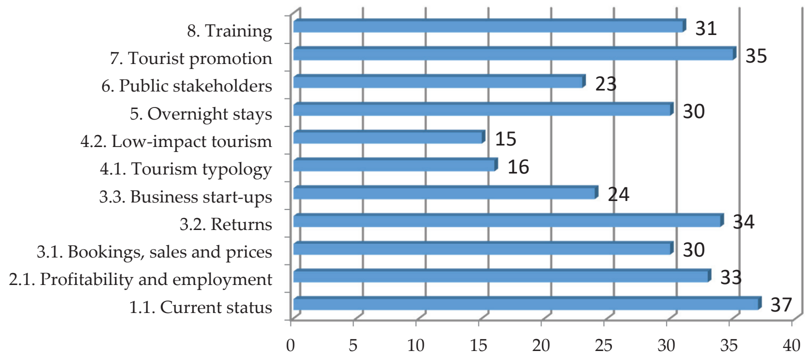

Figure 2. Discursive axes of all focus groups (absolute values: number of mentions). Source: own elaboration.

Table 4. Discursive axes (mentions) of the specific focus groups (absolute values).

	BADAJOZ	CÁCERES	MÉRIDA	ZAFRA	PLASENCIA	GUADALUPE	Total
			Discursive axes				
1.1. Current status	7	7	7	6	5	5	37
2.1. Profitability and employment	6	7	5	6	5	4	33
3.1. Bookings, sales, and prices	7	6	5	5	4	3	30
3.2. Returns	7	6	7	5	4	5	34
3.3. Business start-ups	3	6	4	4	3	4	24
4.1. Tourism typology	3	3	3	2	3	2	16
4.2. Low-impact tourism	3	3	3	2	2	2	15
5. Overnight stays	6	6	7	4	4	3	30
6. Public stakeholders	4	6	5	3	3	2	23
7. Tourist promotion	7	6	7	6	5	4	35
8. Training	6	6	6	4	5	4	31
Total references per FG	59	62	59	47	43	38	308
			Participants/time				
Number of participants in each FG	6	9	5	6	7	5	38
Time in minutes of each FG	120′	130′	85′	120′	115′	80′	650′

Source: own elaboration.

On the other hand, we made an approximation of the productivity of these groups. The development of the six focus groups involved a total of 10 h and 80 min of discourse on tourism in Extremadura by the stakeholders.

A correlation analysis [60] allows us to evaluate the performance of the groups (Table 5). In global terms, the relationship between the number of participants, the number of mentions, and the duration of the sessions shows that the longer the sessions last, the more productive the group is (correlation 0.95). While the number of participants has less of an effect on productivity, the correlation is low (0.49). As for the production of the specific groups, Table 5 shows that the Zafra group (0.94) has the highest correlation between the number of contributions made (mentions) and the total contributions made by all the groups; we could say that it is the "most productive" group. This is followed by Badajoz and Plasencia. It should be noted that the productivity of a group, in terms of the amount of discourse it is able to generate, also has much to do with the skills of the moderator of the sessions, and even the time of day at which a session is held and the location of the session; aspects that we have not evaluated in this study [12].

Table 5. Focus group performance indicators.

	Correlation
GLOBAL PERFORMANCE INDICATORS	
Time/total references (mentions)	0.95
Number of participants/time	0.79
Number of participants/mentions	0.49
PERFORMANCE INDICATORS BY FG, According to the number of mentions they produce, in relation to the total.	
ZAFRA	0.94
BADAJOZ	0.92
PLASENCIA	0.91
MÉRIDA	0.89
CÁCERES	0.87
GUADALUPE	0.84

Source: own elaboration.

Finally, we would like to explain that certain aspects that were to be dealt with in the groups and that were fixed in advance by the researchers, were not dealt with specifically by the participants (we refer to items 1.2 and 2.2 in Table 2). In the cases of those referring to propositions 5, 6, 7, and 8, which we have broken down into several sub-categories in Table 2, they were treated jointly by many of the participants in the groups, so we will refer to them with a single digit.

5. Results

General Discourse Analysis

The first approach to the analysis of the discourse of the focus groups has been carried out by means of a "tree of relationships", which hierarchically integrates each of the sets of ideas and opinions expressed (Figure 3). The different contributions flow from the axis "training" + "municipal intervention" in tourism, in line with Hardy's [16] approaches, and conclude with a certain vision of "the situation", which is, in the opinion of the majority, "regular". Figure 3 shows the most significant literal expressions; those that best summarize the opinion of the group as a whole.

The "relationship tree" shows the links that we discovered between the questions posed by the moderators in the propositions we formulated in Table 2 and the responses obtained. This initial phase, for all the focus groups, makes it possible to observe the structure of the links between the different issues under discussion. Figure 4 shows the sequencing of the factors that generate what we can describe as the "tourism situation" (Proposition 1). The aim is to answer the question: What is the order of factors that define the tourism situation in Extremadura? To do this, we start with the following descriptors, which, in essence, order and hierarchize the propositions and codes generated in the project.

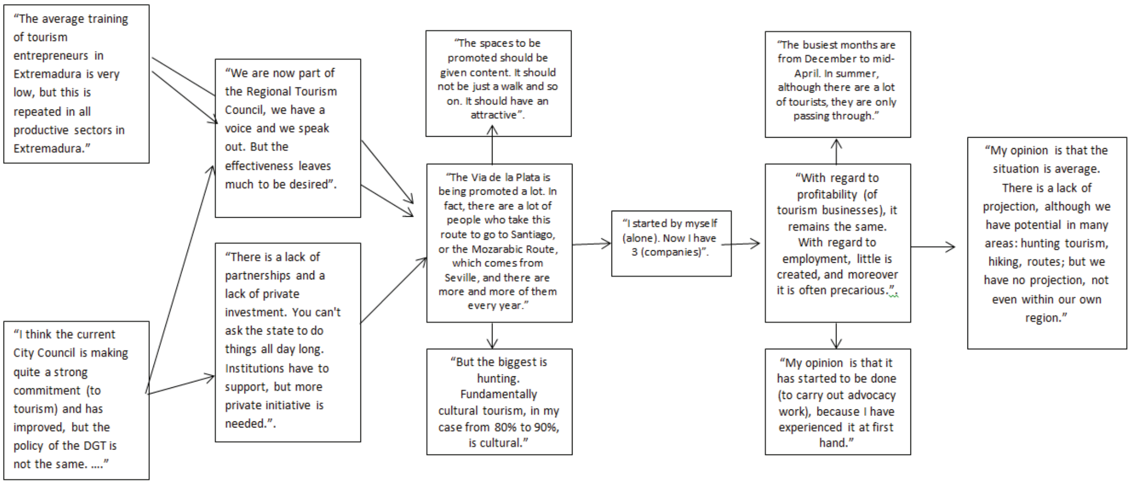

Figure 3. Relationship tree for the set of contributions from the focus groups in Extremadura. Source: own elaboration.

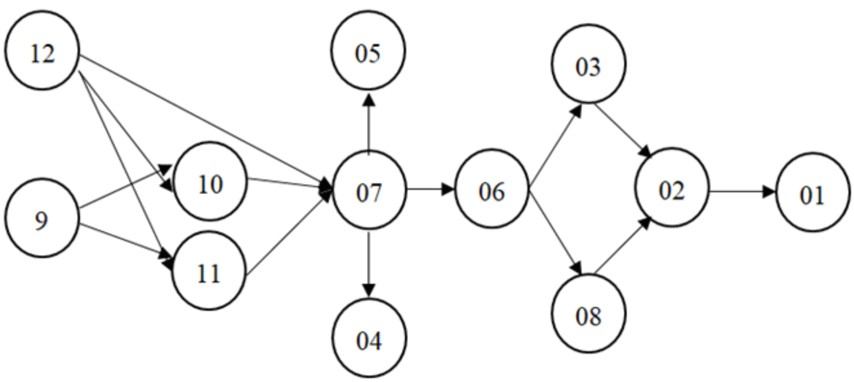

Figure 4. Sequencing of tourist elements to develop tourism in Extremadura. Source: own elaboration based on speech processing with ATLAS.ti software.

In general terms, and by way of an explanation of Figure 4 and Table 6, all the issues discussed in the six focus groups seem to have in common a demand, sometimes more explicit and sometimes latent: the need to increase the training of tourism professionals (12, Proposition 8, in accordance with the proposals of Wilson, Fesenmaier, Fesenm, and Van Es [51]), with a triple purpose:

a. Firstly, to move from being agents who inform public policies to agents who "contribute" to these policies; that is, to take a step further in their involvement as part of the human team that designs public policies (10, Proposition 6, in accordance with Buhalis and Michopoulou [55]) and the promotion of tourism in the region (11, Proposition 7, according to González-Herrera and Álvarez-Hernández [52] and to Buhalis and Michopoulou [55]).
b. Promote a shift that reinforces the coordination of tourism policies (in which, in addition to the Regional Government, provincial governments and municipalities are competent) (09, Proposition 6). This "shift" also implies involving the private sector in the design of public policies (10, Proposition 6), and in tourism promotion (11, Proposition 7).

c. Both the training of tourism professionals (12, Proposition 8) and the active role of the private sector (10; 11, Proposition 6 and 7), and the correct design of public policies by the regional administration, in the opinion of the focus group members, should contribute decisively to obtaining the necessary return on investment (07, Proposition 2 and 3, in line with Wilson, Fesenmaier, Fesenm, and Van Es [51], with Lindroth, Ritalahti, and Soisalon [21], and with Aichholzer [58]) in tourism activities in Extremadura.

Table 6. Figure 4 codes interpretation.

Figure 4 Code	Meaning
01	Improvement of the situation of tourism in Extremadura
02	Improvement in profitability and employment in the region
03	Increase in reservations and sales
04	Types of tourism
05	Tourism that is considered to have a low impact or which has the potential for a greater impulse
06	Return on investment to the private sector
07	Return on investment in tourism activities
08	Increase in the average rate of overnight stays
09	Coordination of tourism policies (in which, in addition to the Regional Government, provincial governments and municipalities are competent)
10	Public policies' design
11	Promotion of tourism in the region
12	Training of tourism professionals

Source: own elaboration.

In principle, it can be interpreted that the characteristics of each area will have an effect on the types of tourism (04, Proposition 4, according to Strielkowski, Riganti, and Wang [15] and to Jacobsen [11]), especially with tourism that is considered to have a low impact (05, Proposition 8) or which has the potential for a greater impulse, depending on the area in question.

This return on investment to the private sector makes the tourism industry a business-creating sector (06, Proposition 82), whose immediate effects will be an increase in reservations and sales (03) and an increase in the average rate of overnight stays (08; Proposition 5) in the region.

This relational approach allows us to discover that both factors, in the opinion of the participants in the focus groups, are those that will best contribute to the improvement in profitability and employment in the region (02, Proposition 1) and, finally, to the improvement of the situation of tourism in Extremadura (01, Proposition 1).

As can be seen in the diagram (Figure 4 and Table 6), training (12, Proposition 8) is considered an essential element in the process of building a sustainable tourism system. If we analyze the importance given to the training factor by the different discussion groups (see Table 5), it has an important weight within the sector. If not the main factor, it is a second group of concerns. For example, in the Plasencia focus group, it occupied first place among the concerns of the participants, together with economic profitability and tourism promotion.

6. Discussion

The results of this research are noteworthy, because the analysis of the different stakeholders' opinions reveals that they emphasize the training of human capital in the tourism sector. The tourism activity has relatively little added value in the economic system of a region similar to that studied, where the primary sector is still very relevant, which means that the participants in the groups tend to consider that increasing the value of tourism products involves giving priority to the quality of training. In works such as that of Hughes [56], which studies the factors that affect the satisfaction of the tourist experience, the training of the guides is pointed out; but it is quality that makes a greater perception of similarity between the values, expectations, and experiences of the tourists and their guide possible. Let us say that the guide must "measure up" to the group, as a necessary condition. Training, here, is a factor, not a condition for the sustainability of the business, as occurs in what we discovered in our work in Extremadura.

Behringer, Buerki and Fuhrer [54] are more in line with our findings. The discussion groups emphasize training as a necessary condition for the challenge of reconversion of the tourism sector in the face of changes in demand resulting from the effects of climate change. Here, training is conceived as a source of innovation, which should contribute to tourism management strategies in the mountainous regions of the Alps, which are heavily affected by global warming and melting ice. Additionally, in this line, we have to point out the research of Wilson, Fesenmaier, Fesenm, and Van Es [51], who studied the factors that help rural communities to successfully develop tourism and its entrepreneurial opportunities, based on several focus groups with entrepreneurs and local leaders in Illinois. Again, human capital formation allows for the adaptation of resources and the implementation of a rural tourism offer adapted to the demands of a given location and the maintenance of environments in a sustainable manner.

In any case, training as an implicit demand of the tourism sector must be included among the social effects that the development of this sector has on the receiving regions, especially when they are eminently rural and relatively undeveloped, as is the case of Extremadura. These effects, already highlighted by Ruiz Olabuénaga [61] in the 1990s, apply, in our opinion, to the changes that tourism generates in Extremadura and the sequence that makes it necessary to train human capital to meet the new demands. The most visible changes are in the social structure of the population, especially in the professional structure, the income structure, the occupational level, and in the remodeling of the social classes. The opening of new hotels, the boom in commerce, transport, and services led to the development of new occupations and professions and with it an increase in the income of the members of the host society. At the same time, the increase in the income levels of the population favors the development of the educational system, which has to attend to the training of new professionals and boost their levels of consumption, encouraged by the new levels of purchasing power, as well as by the new social aspirations to imitate the lifestyles of the affluent visitors [62].

Training, as a key factor for improving tourism supply, should consider other factors that, in addition to the quality of the tourism service itself, also affect consumer perception and behavior. Some of these factors have been highlighted by classic studies, such as those of John Urry [63], and by more recent ones, such as those of Light [64]. Light explains how visitor empathy is an important factor in improving customer response, so that the training of professionals in the sector should also have an impact on improving this factor.

On the other hand, it is evident that tourism professionals should also bear in mind the emergence of new typologies or variants within tourism that do not seek only sun and beach, such as, for example, educational or training tourism or mass tourism, derived from the idiosyncrasies of the new tourist destinations that are emerging [64,65]. The agents of the sector, especially in rural regions such as Extremadura, should be aware of the relations with nearby urban environments. Tourism mobility [66] of medium distance, since short-radius trips, of one day or one weekend duration, represents most of the tourist activity that takes place in rural inland tourist regions, such as Extremadura.

Finally, a factor that is hardly considered in the training of tourism professionals is the geopolitical changes occurring in nearby international environments, such as the changes in political regimes in North Africa or in Central and Eastern Europe (CEE) [64,65], which have only recently enjoyed democratic political systems. This turns these countries into alternative destinations that, as they are perceived as safer, attract more tourists, due to their greater economic competitiveness, their novelty, and their picturesque characteristics (language, culture, landscapes, and traditions very different from the more consolidated destinations).

7. Conclusions

The analysis of the discourse of the six focus groups led to a series of conclusions that, in general, are congruent with other sources of data, such as the standardized surveys of businesspeople and the semi-directive interviews that we conducted with an important group of socio-economic actors in the sector. These conclusions point to the fact that, of all the problems under discussion, and, therefore, of concern among stakeholders, three major groups can be classified according to the volume of data generated about them.

The first joint discussion axis was the "evaluation of the sector considering returns and promotion", which refers to the situation of the tourism sector in the area/region, and the return on investment and tourism promotion. Together these thematic axes occupy a third of the content of all the debates. The groups focused a large part of their contributions on analyzing the situation of the sector, and many of the contributions were critical, with proposals for improvement; but others were centered on assessing the progress to date (from before the coronavirus health crisis). The problem of tourist promotion is something that worries most of the localities, although in places similar to Cáceres and Guadalupe, there was less insistence on this. Additionally, the problem of the delay of investments has been very present in the debates of Badajoz, Mérida and Guadalupe.

The second joint discussion axis involved "training for tourism take-off", the profitability of the business, established in sales, bookings, prices, and overnight stays, in the training of human capital. These are the thematic axes that have a secondary weight in the debates, but which are transversal to all the groups. From our point of view, there is a link between all these aspects, which has been highlighted in the analysis of Figures 3 and 4. Training is probably the necessary condition for generating complementary offers and reinforcing the quality of tourist services, which in turn will contribute to increasing overnight stays in Extremadura and ensuring the profitability of businesses.

The third axis of discussion offers a great dispersion of aspects, only linked together because they were found to be the least important in the discussions of the focus groups as a whole. In this category we include the topic of business creation. The issue of tourism entrepreneurship does not seem to be a major concern among stakeholders. Another axis of discussion that occupied the debate, but with little intensity, was the role of social actors in the articulation of the sector; in Cáceres, this is the most relevant (9.7%). In general, the promotion of types of tourism that are not well exploited, or the search for new segments, was of less interest to all the groups.

One of the limitations of this work is the lack of participation in the focus groups of a significant percentage of the "key informants" selected and invited. Thus, for example, it can be seen that 84 people were invited to participate in these dynamics (Table 2), while 38 people actually attended the focus groups, that is, only 45.2% of those invited. This deviation introduces biases in the representation in the groups of some important sectors of the interest groups, specifically the one referring to the private initiative sector (urban entrepreneur and tourism business association), which causes systematic errors in the coverage of the initial sample.

In spite of this, we consider this work to be an interesting contribution to research on tourism planning and management in rural areas characterized by low population densities, highlighting the importance of taking into consideration the contributions, opinions, and know-how of the social and economic agents involved in the tourism sector as a key element of analysis.

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Article

Tourism-Related Facility Development in Sagarmatha (Mount Everest) National Park and Buffer Zone, Nepal Himalaya

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Abstract: The increase in the number of tourists to mountain regions poses both opportunities and challenges for sustainable mountain development. In order to achieve sustainable development, it is essential to examine societal, landscape, and population transformation in mountain regions. This study explores transformation in the context of the tourism-related facility in Sagarmatha National Park and Buffer Zone (SNPBZ) of Nepal as an example of the Himalayan region. Questionnaire surveys targeting the owners and managers of tourism-related facilities and interview surveys with various community leaders, officials, and school principals were conducted in the park in 2017–2019. Both surveys show that the types, ownership, distribution, and capacity of facilities in the park have been transformed. Growth of tourist numbers, improvement of porters' accommodation conditions, and migrant labor are the main factors driving the transformation. Tourism has also induced imbalanced development and unequal benefits among the villages in the park. The findings suggest that diversification of trekking routes and facility and service quality improvement could help to mitigate imbalanced development and unequal benefits. The in-depth examination of the transformation of tourism-related facilities augments the knowledge of the dynamic changes of facilities in mountain regions, which is vital for sustainable mountain development.

Keywords: mountain region; facility status transformation; imbalanced tourism development; unequal benefits; sustainable tourism; Sagarmatha National Park and Buffer Zone (SNPBZ)

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1. Introduction

Rural areas have long been regarded as suitable locations for tourism, which has been an economic contributor to the areas [1]. The rapid development of tourism has brought extraordinary changes in rural areas' economic, social, cultural, and environmental conditions [2]. Many rural areas are experiencing landscape changes generated by rural tourism [3]. Over the past four decades, rural economic development, rural settlement patterns and communities, population, migration, and social structure have been identified as the traditional concerns of rural geographers [4]. Recent studies have shifted from the physical form of rural settlements to the social dimensions of the rural community [4]. However, little analytical and exhaustive research has been conducted on the relationship between the imbalanced social composition of rural areas, the spatially uneven development of tourism, and the problematic relationship between the two [5]. Further, the review of previous works has shown considerably less research relating to developing countries [1].

Mountains, characterized by fragile and dynamic environments, are home to rural indigenous communities [6] and have long been widely indispensable as places of important cultural significance [7]. Thus, nature and culture-based tourism have prevailed as economic pathways for rural communities in mountain areas [8,9]. Many mountain regions have fostered tourism development to boost their economies through the provision of direct income and employment opportunities to local residents [10]. Thriving mountain tourism has also accelerated built-up expansion to accommodate many tourists, leading to the modification of the rural landscape [5]. Studies have explored tourism-induced changes in the features and functions of rural settlements [5,10–13]. However, these studies offer limited investigation and analyses about the underlying processes and challenges of the resultant growth of different types of tourism-related facilities and distribution patterns. Mountain tourism is unevenly distributed globally, and its benefits are unequally scattered from the local to the national level [7]. This often results in limited community engagement in tourism development [14–16]. In Turkey, although tourism has accelerated economic growth, it has also resulted in imbalanced development between coastal and remote regions [17]. In the tourism service-dependent states of the USA, patterns and trends of income disparity have been observed [18]. In central Botswana, residents of the Serowe village have greater decision-making power due to the village's advantage in population size and gain more than those in other villages surrounding Khama Rhino Sanctuary Trust [19]. In Huang Shan Scenic Park of China, tourism has widened the income gap within buffer communities, although it has also stimulated regional development [20]. Such imbalanced development and unequal benefits matter, as they affect poverty reduction, social cohesion [21,22], political stability, and other aspects of social development [23], which might subsequently affect future tourism sustainability. Moreover, [24] pointed out that research in sustainable mountain development is insufficient, with limited knowledge provided on the different drivers of mountain ecosystems or human migration to and from mountain regions. Tourism is the primary source of foreign exchange and revenue in Nepal [25]. The magnificently disparate natural landscape and rich cultural heritage have promoted the rapid development of tourism in the country. Since foreigners were first allowed to visit Nepal in 1951, the number of tourists has increased significantly, from 9526 in 1964 to 1,197,191 in 2019 [25]. Trekking and mountaineering are the leading tourist activities in Nepal; the total number of trekkers and mountaineers to the country was 197,786 in 2019 [25]. Sagarmatha National Park and Buffer Zone (SNPBZ) (Figure 1), one of the top trekking destinations in Nepal, had the third-largest number of tourists in 2019 [25].

Since the first arranged commercial trek started in the Everest region (current SNPBZ area) in 1966, mountaineering and trekking activities have flourished, bringing far-reaching social and environmental changes to SNPBZ [26–31]. Local people residing in the region are mainly Sherpas, and their participation in tourism has led to remarkable changes in their lifestyles [32]. Furthermore, [32–36] discussed the impact of tourism on mountain residents' cultural values and lifestyles.

Wealth derived from tourism is retained mainly by a small number of Sherpa families in SNPBZ [10]. The distribution of tourism benefits is unequal among local Sherpas and between local Sherpas and other ethnic groups [32,36,37]. Uneven power structures and income differences at the village level are obstacles to executing rural development plans in the park [10]. Moreover, [20] noted that sustainability on different scales is important in forming sustainable development in a certain area. However, no detailed suggestions have been provided to date for mitigating imbalanced development and unequal benefits in the park.

Tourism-related facilities have flourished with an increasing number of tourists in SNPBZ. There has been a proliferation of shops and teashops serving snacks and lunch for tourists and porterhouses serving meals for trekking guides and porters along the trekking routes [30]. Although some previous studies have discussed changes and growth of settlements in SNPBZ [10,38], there is little comprehensive knowledge on the diversification, management, and ownership of tourism-related facilities. Furthermore, there is insufficient explanation of the factors that drive facility development changes and the challenges pertaining to the unequal distribution of tourism income.

Thus, this study aims to (1) examine the current status of tourism-related facilities in terms of their types, management, distribution, growth, capacity, and plans for future expansion in SNPBZ; (2) analyze the impact of the development of tourism-related facilities on local communities; and (3) investigate the factors contributing to the diversification of tourism-related facilities. Moreover, it intends to yield a more up-to-date understanding of the evolution and present status of tourism-related facilities and the imbalanced development and unequal benefit distribution in SNPBZ through answering the following research questions: (1) what are the tourism-related facilities in SNPBZ and who manages them?; (2) how are tourism-related facilities distributed in the park and what factors influence their distribution?; and (3) what types of problems have been induced by tourism-related facilities and what measures could be taken to mitigate these challenges?

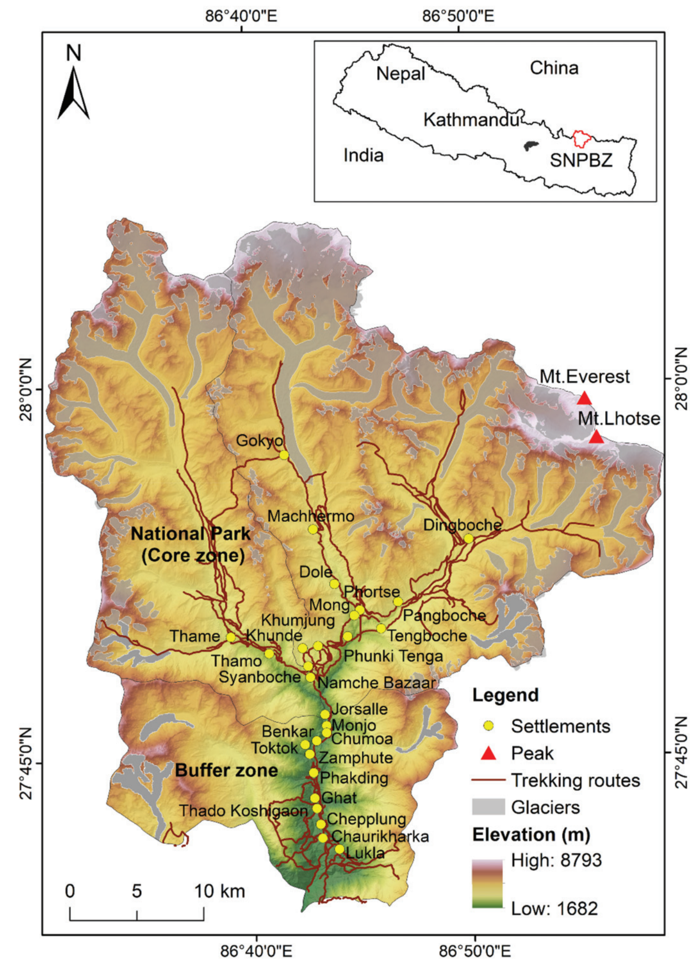

Figure 1. Study area.

By investigating the three analytical points and answering the three research questions, this study enhances the literature of the case studies of international tourism-induced rural landscape changes in developing countries. In addition, the results deliver an efficient basis for creating sustainability in remote and isolated areas.

2. Study Area

Established in 1976, the park (Figure 1) was declared a World Heritage Site in 1979 for its prominent natural and cultural resources [32]. Located in the world's highest ecological system, the core zone of the national park area covers about 1148 km^2. The southern area of the park is adjoined by a 275 km^2 buffer zone created in 2002. The landscape incorporates mountains, glaciers, and rivers, ranging from 2800 to 8848 m. In 1953, the first successful summit of Mount Everest (Qomolangma) made the area famous among international mountaineers and explorers [39]. However, it was difficult to visit the park in the 1950s. When the Lukla airstrip was built in 1964, conditions changed remarkably [40]. Trekking and mountaineering activities are usually conducted in spring and fall. The number of tourists to SNPBZ increased from 5836 in 1980 to 52,424 in 2019 (Figure 2). Tourists visiting SNPBZ are principally international tourists from UK, USA, Japan, Germany, and Australia [40,41]. These tourists cover all generations varying from 20 to 60 years old [40]. They travel primarily in organized groups. Due to the limited transportation facility, porters and livestock usually carry group tourists' luggage (Figure 3). Almost all tourists stay in lodges. They visit SNPBZ primarily for trekking, enjoying the scenery, and viewing Mount Everest [41].

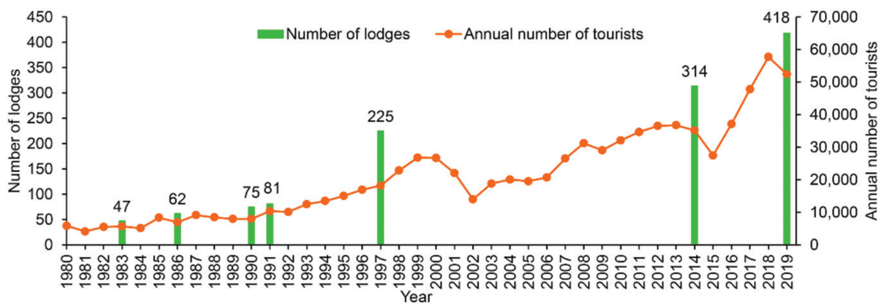

Figure 2. Number of lodges in SNPBZ and the annual number of tourists to SNPBZ. Sources: Developed by the authors based on [25,30,42,43]; SNP Jorsalle Entry Point, November 2017 and May 2019; and field survey.

Figure 3. Porters and livestock carrying tourists' luggage in the park (Photograph was taken by Y.S. on 19 October, 2018). SNPBZ is administratively part of the Solukhumbu District. The human population in the park increased from 3465 in 1991 to 7161 in 2011 [44,45]. Sherpas dominate the population, followed by Rai, Tamang, and other ethnic groups. The main settlements are Namche Bazaar, Khumjung, Khunde, Phortse, Pangboche, Thame, and Dingboche. Lukla is the entrance village to the park, and Namche Bazaar is the park's administrative, commercial, and tourist center.

Sherpas began to set up tourism enterprises in the late 1960s, and 15% of the families ran family lodges or shops in the mid-1980s [36]. The first shop was opened in Namche Bazaar in 1967 [10], and by the spring of 1991, 21 shops were operating there [43]. The first Sherpa lodge was constructed near Namche Bazaar in 1971 [36]. A boom in lodge development was observed in the 1980s [43]. Many Sherpas have rebuilt their houses into lodges and shops to accommodate the increasing number of tourists, which has brought notable changes in the expansion of the built-up areas [10]. Lodges have become an increasingly important part of the local economy [30]. There were 418 lodges in the park in 2019, when the field survey was conducted.

3. Methods

This research implements a case study approach to examine rural landscape changes induced by tourism and the implied transformation's contributing factors and challenges [11]. Case studies are vital in exploring one or more bounded systems over time through multiple sources of information to obtain a thorough understanding of individuals and communities in their natural settings [46]. SNPBZ was selected because of the authors' familiarity, the importance of tourism in the region, the rapid increase in the number of tourists visiting the park, and its topography that allows people to enter into the national park area through one route, which enabled us to understand the accurate picture of peoples' mobility. These criteria are helpful to select an area characterized by a sufficiently important tourism activity so as to examine the manifold transformation of tourism-related facilities and their resultant challenges.

This study employed a mixed method to incorporate face-to-face questionnaire and semi-structured interview surveys to collect data in the field. As a quantitative method, the questionnaire has been largely used to investigate tourism-induced rural settlement changes [5,10–13]. A semi-structured interview is an extensive method to collect rich and detailed data which can provide a holistic understanding of the phenomena under investigation [11], and has been effectively practiced by previous studies about rural landscape changes and rural tourism [11,47]. Questions of the questionnaire and semi-structured surveys were adapted from [5,10,28], and further expanded to deepen the understanding of the evolution of tourism-related facilities in SNPBZ (see Supplementary Materials Tables S1–S3).

3.1. Questionnaire Surveys

This study prepared two forms of questionnaire surveys: one for lodges and another for other tourism-related facilities. The reasons lie that tourists mainly stay in lodges [40], and lodging facilities are the most important tourism-related facilities in SNPBZ [30].

Since there is no exact total number of tourism-related facilities in the park, this study referred to the most recent information on population size from the 2011 national census. In 2011, the total human population in the park was 7161 [44]. Therefore, according to [48], when the confidence level is 95% and $p = 0.5$, the supposed sample size for 7000 people should be 378, while this study collected 536 sets of answers between November 2017 and June 2019 and tried to finish surveying all the facilities in each village to make sure the data completeness.

Questionnaire surveys were conducted face-to-face through purposive sampling from the buffer zone to the core zone. On the basis of an extensive literature review, questions were prepared in English. The questionnaire was reviewed by three researchers who had conducted research activities in the park for a long time. A pilot survey was carried out after the questionnaire was translated into Nepali with the help of two Nepalese researchers during the first fieldwork in March 2017. After the pilot survey, a final improved version of the questionnaire was prepared. Most of the target respondents were able to understand English; however, a well-trained research assistant who was familiar with the area and fluent in English was employed as an interpreter whenever the questionnaire survey was conducted. When respondents did not understand English, the research assistant interpreted the questions from English to Nepali and the answers from Nepali to English.

The targets of the questionnaire surveys were owners and managers of tourism-related facilities. The number of investigated lodges was 318, corresponding to 76.1% of the total number of lodges in the park in 2019. The questions contained in the two questionnaire surveys were almost the same, except that there was an additional part for lodge information in the questionnaire for lodges. The questionnaire for lodges consisted of 48 questions and was divided into four parts: lodge, household, personal, and tourism-related information. The questionnaire for other facilities included 29 questions and was divided into three parts: household, personal, and tourism-related information. Answers were collected on the types of facilities, ownership, capacity (lodge), and plans for future expansion (lodge). In the tourism-related information section, questions based on a five-point Likert scale were used to evaluate respondents' satisfaction with tourism in the park, and two multiple-choice questions about the perceived benefits and costs in the park were asked.

The gender ratio of the respondents was 55% men and 45% women (Table 1). Most of the respondents were aged 31–40 years (31.9%). Local Sherpas accounted for 48.7% of the sample. Most migrants (92.8%) had come to the park for job opportunities, while 6.8% had come for marriage and 0.4% had fled natural disasters.

Table 1. Demographic information of respondents (n = 536).

Variable	Category	Number of Respondents	Percentage
Gender	Male	295	55.0
	Female	241	45.0
	Total	536	100.0
Age (years)	Under 30	153	28.5
	31–40	171	31.9
	41–50	119	22.2
	Over 50	93	17.4
	Total	536	100.0
Ethnicity	Local Sherpa	261	48.7
	Local non-Sherpa	10	1.9
	Migrant Sherpa	51	9.5
	Migrant non-Sherpa	214	39.9
	Total	536	100.0

Source: Developed by the authors based on the questionnaire surveys.

3.2. Interview Surveys

Semi-structured interviews were conducted either in Nepali or English with 12 local community leaders, 5 national-park officials, and 2 school principals between 2017 and 2019. The obtained information concerned the history of tourism development, national-park management policies and plans, attitudes toward current tourism development, perceived benefits, and costs in the park.

3.3. Data Analysis

This study distinguished respondents' origin based on two categories: locals and migrants. Locals are those originally resident in SNPBZ, while migrants are from outside the park. Moreover, this study classified tourism-related facilities into four categories: lodges, shops, teashops, and porterhouses. Lodges are accommodations where tourists can stay overnight, sleep, and eat food; shops sell various goods; teashops serve drinks and food to tourists and residents (e.g., restaurants, cafés, and pubs); and porterhouses (Figure 4) generally offer food and accommodation to porters and trekking guides. Table 2 shows the number of respondents from each type of tourism-related facility.

Figure 4. One porterhouse in Phakding (2640 m) (Photograph was taken by Y.S. on November 14, 2018).

Table 2. Surveyed facilities (n = 536).

Category	Buffer Zone	Core Zone	Total
Lodge	136	182	318
Shop	36	65	101
Teashop	36	28	64
Porterhouse	25	28	53
Total	233	303	536

Source: Developed by the authors based on the questionnaire surveys.

This study classified these types of facilities into three categories: owned, bought, and rented. "Owned" refers to facilities built by the respondents themselves and managed either by themselves or by employees; "bought" refers to facilities purchased by respondents and managed either by themselves or by employees; and "rented" refers to rented facilities. This study analyzed data from the buffer zone and core zone separately when necessary. Data were analyzed using SPSS, version 25. A Chi-square test was performed to analyze the relationship between altitude and distribution of facilities. Results are mainly descriptive, intending to analyze key processes of tourism-induced changes in management, ownership, growth, and distribution of facilities.

4. Results

4.1. Types of Tourism-Related Facility Ownership

The results of the survey showed that shops, teashops, and porterhouses were mainly rented in both zones (Table 3). Lodges were mostly owned in both zones, with a higher percentage in the core zone (80.2%). In total, 14 facilities were bought, among which 12 (85.7%) were in the buffer zone.

Table 3. Types of facilities (n = 536).

Variable	Category	Type of Facility		
		Owned (%) (n = 275)	**Bought (%) (n = 14)**	**Rented (%) (n = 247)**
Buffer zone	Lodge (n = 136)	66.2	7.4	26.5
	Shop (n = 36)	19.4	2.8	77.8
	Teashop (n = 36)	33.3	0.0	66.7
	Porterhouse (n = 25)	4.0	4.0	92.0
	Subtotal (n = 233)	47.2	5.2	47.6
Core zone	Lodge (n = 182)	80.2	0.5	19.2
	Shop (n = 65)	7.7	0.0	92.3
	Teashop (n = 28)	35.7	3.6	60.7
	Porterhouse (n = 28)	14.3	0.0	85.7
	Subtotal (n = 303)	54.5	0.7	44.9
Total (n = 536)		51.3	2.6	46.1

Source: Developed by the authors based on the questionnaire surveys.

The survey results also showed that owned facilities were the highest in number, at 275 (51.3%), followed by rented facilities at 247 (46.1%) and bought facilities at 14 (2.6%) (Tables 3 and 4).

Table 4. Ethnicity of surveyed facilities' owners and managers (n = 536).

Variable	Category	Ethnicity			
		Local Sherpa (%) (n = 268)	**Local Non-Sherpa (%) (n = 12)**	**Migrant Sherpa (%) (n = 47)**	**Migrant Non-Sherpa (%) (n = 209)**
Owned facilities	Lodge (n = 236)	89.0	1.3	3.8	5.9
	Shop (n = 12)	16.7	8.3	16.7	58.3
	Teashop (n = 22)	54.5	18.2	0.0	27.3
	Porterhouse (n = 5)	100.0	0.0	0.0	0.0
	Subtotal (n = 275)	83.3	2.9	4.0	9.8
Bought facilities	Lodge (n = 11)	45.5	0.0	18.2	36.4
	Shop (n = 1)	0.0	0.0	0.0	100.0
	Teashop (n = 1)	100.0	0.0	0.0	0.0
	Porterhouse (n = 1)	0.0	0.0	0.0	100.0
	Subtotal (n = 14)	42.9	0.0	14.3	42.9
Rented facilities	Lodge (n = 71)	31.0	0.0	16.9	52.1
	Shop (n = 88)	5.7	1.1	12.5	80.7
	Teashop (n = 41)	9.8	0.0	19.5	70.7
	Porterhouse (n = 47)	4.3	2.1	10.6	83.0
	Subtotal (n = 247)	13.4	0.8	14.6	71.3
Total (n = 536)		50.0	1.9	9.1	39.0

Source: Developed by the authors based on the questionnaire surveys.

Regarding the ethnicity of the facilities' owners and managers, local Sherpas accounted for most of the owned facilities (83.3%), especially lodges (89%) (Table 4). The 14 bought facilities were purchased and managed mainly by local Sherpas (42.9%) and migrant non-Sherpas (42.9%). In terms of rented facilities, 71.3% were occupied by migrant non-Sherpas. Migrant non-Sherpas constituted most of the shop renters (Table 4). Overall, local Sherpas accounted for precisely half of the facilities' owners and managers (50%), followed by migrant non-Sherpas (39%). In total, the proportions of locals and migrants managing the surveyed facilities were 51.9% and 48.1%, respectively.

4.2. Distribution of Tourism-Related Facilities

The spatial distribution of the tourism-related facilities in SNPBZ is shown in Figure 5. Among the 536 surveyed facilities, 233 (43.5%) were located in the buffer zone and 303 (56.5%) in the core zone (Table 3). The results showed that there were more lodges in the core zone (Table 2). Furthermore, investigated facilities were mainly located between 2600 m and 3000 m ($X^2 = 60.473$, $p = 0.000$). Lodges were the dominant type of facility at all elevations (Figure 6). Among the surveyed 318 lodges, 42.8% were located in the buffer zone and 57.2% in the core zone (Table 2).

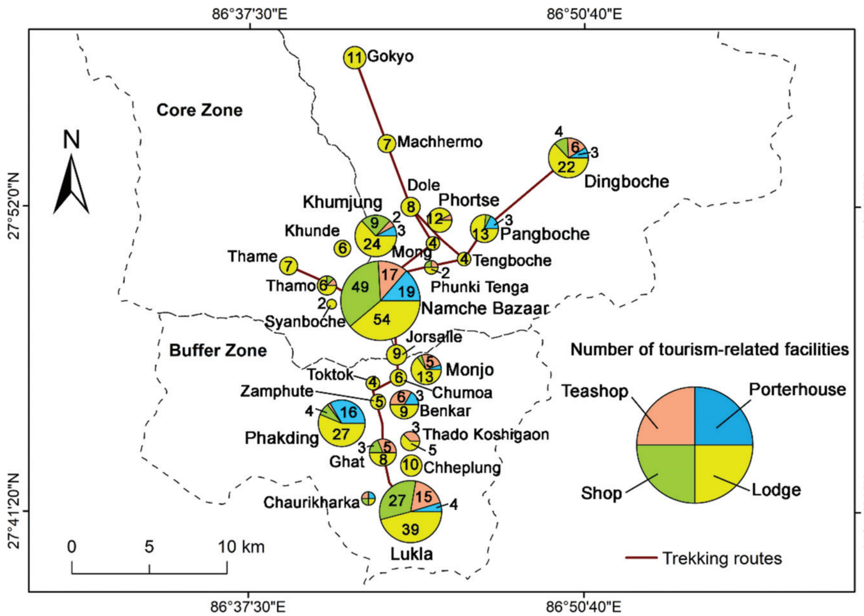

Figure 5. Spatial distribution of surveyed tourism-related facilities in villages in SNPBZ in 2019 (n = 536). Source: Developed by the authors based on the questionnaire surveys.

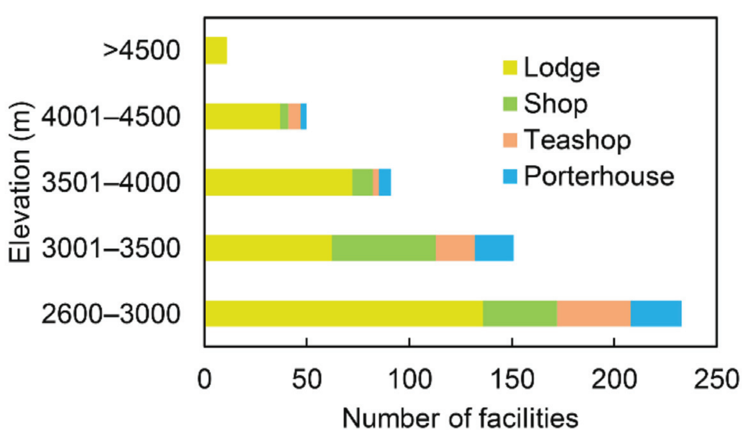

Figure 6. Elevational distribution of tourism-related facilities in 2019 (n = 536). Source: Developed by the authors based on the questionnaire surveys.

Namche Bazaar (Figure 7) had the largest number of facilities (139), followed by Lukla (85) and Phakding (48). Namche Bazaar also had the highest number of lodges (54), shops (49), teashops (17), and porterhouses (19). Villages in which tourists do not stay overnight had a smaller number of facilities, such as Zamphute (5) and Toktok (4), in the buffer zone.

Figure 7. Locations of lodges, shops, teashops, and porterhouses in Namche Bazaar (3450 m) in 2019. Note: L = lodge, S = shop, T = teashop, and P = porterhouse. Source: Developed by the authors based on the questionnaire and field surveys. Base image: Google Earth.

4.3. Development of Lodge Facilities

4.3.1. Increase in Lodge Numbers

The total number of lodges increased from 47 in 1983 [43] to 418 in 2019. Table 5 summarizes the growth of lodges in the major villages from 1997 to 2019. In the buffer zone, the total number of lodges in the studied villages doubled from 1997 to 2019. Lukla, at the entrance to the park, had the largest number of lodges in the buffer zone. The main reason for this is that tourists usually stay at least one night in Lukla before flying back to Kathmandu. Villages that are not the main stops for tourists, such as Toktok, Thado Koshigaon, and Jorsalle, also experienced substantial increases in the number of lodges.

In the core zone, the total number of lodges increased by 81.8% (Table 5). There was no increase in Tengboche, because most of the land there is managed by the Tengboche monastery. Another exception is Thame (Figure 8), where the number of lodges decreased. The interview surveys suggested that two reasons led to this reduction. First, fewer tourists visited Thame than they did the Namche Bazaar–Dingboche and the Namche Bazaar–Gokyo routes. Second, some Sherpa families moved from Thame to seek either better living conditions or education for their children.

Table 5. Growth of lodges in the major villages.

Village	Elevation (m)	Number		Growth Rate/ 12 Years (%)
		1997	2019	
Buffer zone (total)		69	141	104.3
Thado Koshigaon	2600	2	6	200.0
Ghat	2630	6	9	50.0
Phakding	2640	13	27	107.7
Chheplung	2660	5	10	100.0
Zamphute	2680	2	5	150.0
Toktok	2710	1	5	400.0
Benkar	2720	5	9	80.0
Chumoa	2790	4	6	50.0
Jorsalle	2810	3	9	200.0
Monjo	2820	5	13	160.0
Lukla	2850	23	42	82.6
Core zone (total)		99	180	81.8
Namche Bazaar	3450	32	54	68.8
Khumjung	3780	7	27	285.7
Thame	3800	9	8	−11.1
Phortse	3810	6	13	116.7
Khunde	3840	2	6	200.0
Tengboche	3860	5	5	0.0
Mong	3950	2	4	100.0
Pangboche	3985	10	15	50.0
Dole	4040	3	8	166.7
Dingboche	4310	10	22	120.0
Machhermo	4410	5	7	40.0
Gokyo	4750	8	11	37.5

Sources: 1997: [42]; 2019: by field survey.

Figure 8. The largest lodge in Thame (3800 m) (Photography was taken by Y.S. on 31 October 2018).

4.3.2. Lodge Capacity

Lodge capacity data were collected for 302 lodges: 124 lodges in the buffer zone and 178 in the core zone. In total, there were 4569 rooms and 9029 beds (Table 6). There are two types of rooms: one with no bathroom, which is locally called a “common room,” and the other with a private bathroom, which is called an "attached room." An attached room has either only a toilet or both a toilet and a shower. In both the buffer zone and the core zone, there were more common rooms than attached rooms. The average number of beds for a lodge in the buffer zone was 26.9, while that for the core zone was 32.

Table 6. Data on lodge capacity (n = 302).

Village	Elevation (m)	Lodge Number	Total Rooms	Attached Rooms (%)	Common Rooms (%)	Bed Number
Buffer zone (total)		124	1717	24.1	75.9	3340
Thado Koshigaon	2600	5	28	0.0	100.0	56
Ghat	2630	8	63	6.3	93.7	126
Phakding	2640	27	523	31.7	68.3	1024
Chaurikharka	2650	1	4	0.0	100.0	8
Chheplung	2660	10	69	1.4	98.6	141
Zamphute	2680	5	68	17.6	82.4	90
Toktok	2710	4	31	0.0	100.0	57
Benkar	2720	8	72	0.0	100.0	139
Chumoa	2790	6	68	0.0	100.0	135
Jorsalle	2810	8	62	0.0	100.0	121
Monjo	2820	13	243	28.8	71.2	483
Lukla	2850	29	486	33.1	66.9	960
Core zone (total)		178	2852	19.7	80.3	5689
Phunki Tenga	3250	2	18	0.0	100.0	35
Thamo	3440	6	43	11.6	88.4	82
Namche Bazaar	3450	54	1026	28.5	71.5	2036
Khumjung	3780	24	214	10.3	89.7	423
Thame	3800	7	77	20.8	79.2	145
Phortse	3810	8	92	5.4	94.6	176
Syanboche	3830	2	24	75.0	25.0	48
Khunde	3840	6	51	13.7	86.3	101
Tengboche	3860	4	112	0.0	100.0	234
Mong	3950	4	31	0.0	100.0	62
Pangboche	3985	13	164	11.0	89.0	330
Dole	4040	8	140	2.9	97.1	280
Dingboche	4310	22	495	24.8	75.2	1004
Machhermo	4410	7	97	9.3	90.7	194
Gokyo	4750	11	268	15.7	84.3	539
Total		302	4569	21.3	78.7	9029

Source: Developed by the authors based on the questionnaire surveys.

In the buffer zone, lodges in six villages did not have attached rooms while lodges in Lukla had the highest proportion of attached rooms (Table 6). Based on the fieldwork observation and interview surveys, those six villages with no attached rooms in the lodges were mostly used as lunch venues for tourists.

In the core zone, only three villages did not have attached rooms. Syanboche had the largest percentage of attached rooms because of the presence of a luxurious hotel (Hotel Everest View), which offers only such rooms. Namche Bazaar had the greatest number of rooms (1026) and beds (2036), followed by Dingboche and Gokyo. Although Khumjung had the second highest number of lodges, it had fewer rooms and beds. The largest lodge was situated in Gokyo, with 58 rooms and 116 beds.

4.3.3. Future Plans for Lodge Expansion

Among the 318 surveyed lodges, 62.3% (198) did not want to expand their lodges in the future, 19.8% (63) had plans to expand, and 17.9% (57) were uncertain (Figure 9). The main reason the respondents did not want to expand their lodges was the high cost of construction. Nowadays, the national park office allows one household to cut down only three trees when constructing new buildings. Thus, local people have to bring in timber and other construction materials from outside the park, such as the lower part of the Solukhumbu district and Kathmandu.

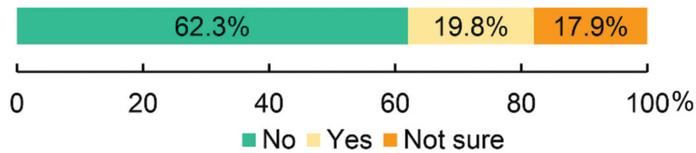

Figure 9. Plans for lodge expansion in the future (n = 318). Note: The survey was conducted between 2017 and 2019, before the start of the COVID-19 pandemic. Source: Developed by the authors based on the questionnaire surveys.

Lodges with expansion plans mainly wanted to increase the number of rooms, attached rooms, and dining space. Among them, 49.2% were in the buffer zone, with Lukla accounting for the most (29%). The rest (50.8%) were in the core zone, of which Namche Bazaar had the most (46.9%).

The results showed that 57 lodges were uncertain about expansion plans because they wanted to check whether the number of tourists would steadily increase. The survey results also indicated that some lodge owners were worried about the risk of losing money to increase the number of rooms if tourist numbers did not increase.

5. Discussion

This study proved the legacy of the past that tourism continues to shape further development in the lodge and other tourism-related facilities in SNPBZ. Previous studies only showed the changes of lodges in their features and functions [10]. In contrast, this study advances the understanding of different types of facilities in terms of their diversification in their ownership, management, regional and village level distribution. Furthermore, though previous studies have already revealed the leadership of Sherpa in commanding the lodging industry in SNPBZ [10,43], detailed percentage data were not provided. This study contributes to this data gap and reveals that the number of migrants accounts significantly in managing the facilities. The following part will thoroughly examine economic, environmental, and social factors contributing to the transformation of the facilities, imbalanced development, and unequal benefits, and will provide detailed recommendations to mitigate the challenges. These are important in understanding the social dimension of the region, broader comprehension of the implications of tourism development for rural settlements, and realizing sustainable mountain development.

5.1. Transformation of the Status of Tourism-Related Facilities

The results of the questionnaire surveys clearly showed that the types, quality, and management of tourism-related facilities in the study area have diversified. Migrants from outside the park searching for job opportunities have provided labor for managing facilities.

5.1.1. Diversification of Tourism-Related Facilities

Tourism fosters economic growth. Tourism-related facilities are diversified in their types, quality, and management in the park. Some of the factors contributing to the diversification of the facilities in SNPBZ include the increase in the number of tourists, improvements in conditions for accommodating trekking guides and porters, and social and cultural transformations among local Sherpas.

First, diversification was the result of an increase in the number of tourists (Figure 2). This finding is consistent with previous studies [10,30]. As stated previously, the number of SNPBZ tourists increased from 5836 in 1980 to 52,424 in 2019 (Figure 2). From 1997 to 2019, the number of tourists increased by 150%, while the total number of lodges increased by 85.8% (Figure 2). A 2007 tourist survey showed that tourists entering SNPBZ comprised 80 different nationalities in the fall and 74 in the spring [40]. Tourists were distributed across a wide age range, which indicates the need for diverse services and extensive quality standards [40]. Various types of facilities (Table 2, Figure 5), such as lodges with attached rooms (Table 6), restaurants with varied menus, cafés, pubs, and mountain equipment shops with superior quality products, have been developed to meet tourists' increasing service demands.

Second, the need to improve the accommodation conditions for trekking guides and porters in the park has contributed to facility diversification. The increase in tourists has created employment opportunities for thousands of trekking guides and porters [30]. Trekking porters usually carry tourists' luggage; however, another type of porter, the commercial porters who carry supplies for tourism-related facilities, has also increased significantly in number [49]. Previous studies have pointed out that porters and trekking guides have led to an increased demand for firewood and waste disposal, which might have posed an environmental threat [50,51]. This was because, in the past, trekking guides and porters usually stayed in tents and used firewood for cooking and heating. However, repeated field observations by the authors showed that porters no longer collect firewood. According to the interview surveys, porters began to be provided shelters in the park in the early 2000s. Nowadays, trekking guides usually eat and sleep in lodges with their customers, while porters and some local trekking guides tend to eat and sleep at teashops and porterhouses. Therefore, they do not need to prepare food or have their own heating sources, which has reduced firewood use and improved waste management. The development of numerous teashops and porterhouses (Table 2, Figure 5) meets the different requirements of tourists and contributes to environmental conservation in the park, although new types of garbage, such as pet bottles, are now left in hidden places [31].

Third, social and cultural transformations among local Sherpas are reflected as a factor contributing to diversification. This factor has been discussed by [52]. Recently, Sherpas have traveled overseas and imported new ideas and customs to meet tourists' desires and preferences, successfully blending tradition and modernity. Tourists to SNPBZ encounter western, Japanese, Chinese, and local menus. Various types of bakeries and pubs are scattered in different villages in the park. In the lodges, modern decorations are intermingled with traditional Sherpa objects.

5.1.2. Migrants' Involvement in Managing Facilities

The increasing number of tourists to SNPBZ has generated various employment opportunities for the locals. Previous studies [30] revealed that local Sherpas in the park had moved on from trekking staff positions and were performing more lucrative jobs, such as lodge owners and outside employment (e.g., owning a trekking company). A similar situation was also recognized in Australia by [53]: local labor was unwilling to be employed in low-paying and seasonal jobs. SNPBZ's tourism-related facilities have experienced significant transformation due to the involvement of migrants (Table 4). In the area, labor shortage in the tourism industry has been filled by immigrants. The significance of migrant labor in the hospitality industry has also been highlighted by [54].

5.2. Imbalanced Development and Unequal Benefits among Villages

The direct impact of tourism benefits among villages in SNPBZ is complex. Some villages, such as Lukla, Phakding, and Namche Bazaar, are more developed than others, such as Chaurikharka, Toktok, and Thame, owing to their location, pre-determined main stops along trekking routes, and well-developed facilities. Therefore, these developed villages accommodate more tourists, which translates to more economic benefits than that of the less developed villages in the park. The seasonality of tourism in the park and the intensity of tourist flow in time and space further deepen the imbalanced development and uneven benefits. Additionally, [36,43] showed the imbalanced development and unequal benefits induced by tourism among different villages and within the same village from as early as the 1990s. The interview surveys in this study indicated that facility location influenced benefits within the same village. Perceived development imbalances among villages (Table 7) could weaken social cohesion and become a severe impediment to future tourism growth [22]. For instance, in Huascaran National Park of Peru, the imbalanced involvement of local communities in tourism projects was shown to cause tensions among villagers [21].

Table 7. Respondents' perceived tourism-led benefits and costs in the park (n = 536).

Category	Item	Number of Respondents	Frequency
Perceived benefits	Increased income from tourism	522	97.4
	Improved living conditions	472	88.1
	Park conservation	110	20.5
	None	7	1.3
Perceived costs	Imbalanced development among villages	365	68.1
	Restrictions of resource use in national park	110	20.5
	Crop losses caused by wildlife	100	18.7
	None	126	23.5

Source: Developed by the authors based on the questionnaire surveys.

Another factor responsible for the imbalanced development and resultant unequal benefits among villages may be the leading role of local Sherpas in the tourism industry of SNPBZ. The dominance of local Sherpas [10,32] in the field has resulted in power disparities and unjust social relations among the local Sherpas and between Sherpas and other ethnic groups [43]. This study demonstrated that local Sherpas dominate the ownership and management of tourism-related facilities (50%) (Table 4). A similar case has also been observed in the Annapurna region, where lodge ownership mainly belongs to a small number of powerful Gurung, Thakali, and Managi families who have dominated the tourism business and had an overwhelming advantage over decision-making in the region [5].

5.3. Recommendations and Their Exportability

Tourism product diversification is crucial for the competitiveness and sustainable development of a particular destination [55]. Some potential tourism products in SNPBZ are cultural viewing, wildlife watching, and bird watching. Moreover, [26,40] found that tourists were often interested in other activities in addition to trekking in SNPBZ. Therefore, incorporating cultural activities and wildlife-related trekking routes may provide alternative attractions and maximize tourist experiences. First, the 19 public monasteries in SNPBZ might be used as cultural attractions. Second, traditional Sherpa festivals during the year can be considered to diversify tourism activities. For example, the Dumje Festival and the Losar Festival could provide good opportunities to attract tourists.

To promote cultural tourism, social media can be beneficial for spreading awareness of Sherpa culture and tourist attractions. The recent "Ding Zhen" effect in China is a successful case of using social media to raise cultural awareness [56]. Further, information about tourist attractions should be made readily accessible to tourists, contrary to the current practice where such information is mostly obtained from books or friends [26,40].

The less developed villages should improve facility and service quality to attract more overnight tourists. Furthermore, [26,40,57] indicated that diarrhea was a common problem that tourists encountered during trekking in SNPBZ. Clean drinking water, well-maintained toilets, and good hygiene in the park are top priorities that tourists want improved. Moreover, as shown in Table 6, some villages do not have lodges with attached rooms. Thus, to attract tourists, these villages should consider increasing the number of attached rooms to facilitate comfortability.

Mountain regions have their specific characteristics, including the difficulty of access and marginality [58]. For example, the topographic barrier of SNPBZ (Figure 10) does not allow people to access essentially except the only route through Lukla. This access route has an analogy with a port on a small island. Therefore, the proposed recommendations above can also be applied not only to other Himalayan regions (including Nepal, India, and Bhutan) with limited access routes, but also to isolated islands with a single port. For instance, Khaptad National Park in the far-western region of Nepal, with its excellent bird-watching resources and rich cultural and religious activities, has a limited number of tourists and popularity [25]. Thus, diversifying tourism products and promoting tourism by using social media can be the strategies for attracting tourists there.

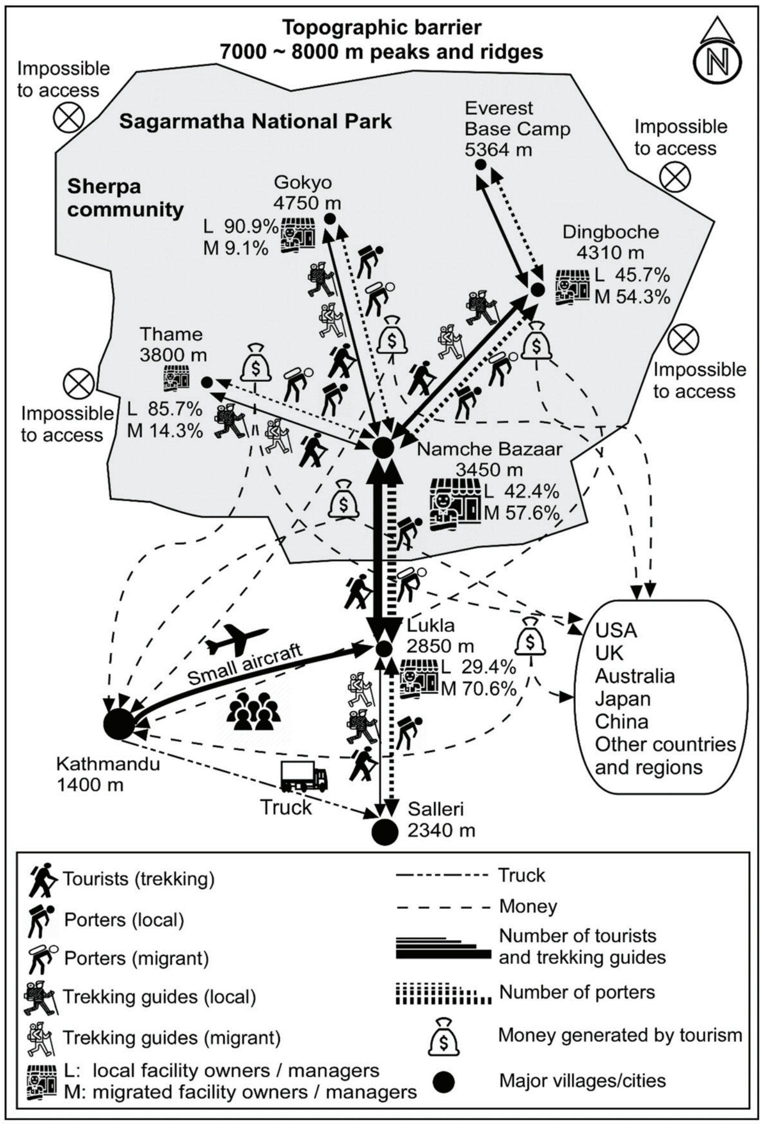

Figure 10. Mobility of people and money in Sagarmatha National Park. Note: The amount of money is unknown. Source: Developed by authors based on social survey.

6. Conclusions

Tourism has brought rapid development to the facilities in SNPBZ. Results of the social survey in this study indicate that the types of tourism-related facilities have been diversified in ownership and management. Migrant non-Sherpas (39%) have been greatly involved in managing the facilities, although local Sherpas (50%) dominate the tourism business in the area.

Tourism-related mobility in SNPBZ is largely constrained by the topographic barrier in the park. The movement of tourists, local people, and cash brought by tourism has produced far-reaching impacts on the transformation of the status of tourism-related facilities and imbalanced development and unequal benefits among villages in the park. The increase in the number of tourists, improved porter accommodation conditions, and higher levels of migrant labor have contributed to the transformation. To balance the development and benefits induced by tourism in SNPBZ, stakeholders, such as park managers, trekking agencies, and local organizations, should consider diversification of trekking routes to incorporate less developed villages. The diversified routes should consider residents' preferences, tourists' travel interests, and tourists' prior trekking experience. Although the diversification of the trekking routes may increase human imprint on the local landscapes and waste accumulation in the region, the increase in human imprint is beyond the focus of this study. Nevertheless, national park authorities and policymakers may consider the potential environmental issues to be brought by the increase in human imprint when the route diversification is developed. Such environmental issues can also be one of the directions of future research. Moreover, diversification of tourism products coupled with improved facility and service quality could help to mitigate further uneven development and unequal benefits in the park.

This study proceeds a step further from previous studies that explored the impact of tourism on changes in settlements by extending the research to the transformation of social dimension in rural communities. Understanding these processes of change is an essential issue for rural development and tourism planning. Moreover, it enriches the literature of rural settlements and rural tourism studies in the developing context. It also contributes to practical and detailed recommendations on how development endeavors could mitigate uneven development and unequal benefits in mountain regions and isolated islands.

Given the impact of the COVID-19 pandemic on international tourism, tourism activities in SNPBZ are likely to have been disrupted. The questionnaire surveys revealed that 63 lodges had plans for future expansion (Figure 9). However, this study is limited by not addressing the impact of COVID-19 on park tourism. The surveys were conducted before the COVID-19 pandemic; therefore, issues related to the expansion of tourism-related facilities in the park need to be re-examined. Further research on how to restore tourism activities in the park is also necessary.

Supplementary Materials: The following are available online at https://www.mdpi.com/article/10.3390/land10090925/s1, Table S1: Questionnaire for lodge owners/managers, Table S2: Questionnaire for other tourism-related facilities, and Table S3: Interview sheet with community leaders, national-park officials and school principals.

Author Contributions: Conceptualization, Y.S. and T.W.; methodology, Y.S.; software, Y.S.; validation, Y.S. and T.W.; formal analysis, Y.S. and T.W.; investigation, Y.S.; resources, Y.S.; data curation, Y.S. and T.W.; writing—original draft preparation, Y.S.; writing—review and editing, T.W.; visualization, Y.S. and T.W.; supervision, T.W.; project administration, T.W.; funding acquisition, Y.S. and T.W. All authors have read and agreed to the published version of the manuscript.

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Article

The Role of Actors in Social Innovation in Rural Areas

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Abstract: Social innovation is gaining momentum in academia, policy and practice, as a process by which local communities generate new social relations and become more capable of addressing social needs and opportunities. However, there is significant ambiguity about the role of the different types of actors involved in social innovation, particularly in rural areas. This article aims to examine which actors make social innovation in rural areas possible, and the roles they play in these processes. Drawing on 33 interviews carried out with key informants of three socially innovative initiatives developed in rural areas of Spain and Scotland, this paper illustrates the scale, role and logic of the actors involved. The findings of the study clarify the central role of local processes and local actors, the impact of facilitators and perceived neutrality. They also show the contribution of social economy organizations as an arena for coordinating plural networks and civil society initiatives. The way the public sector and LEADER participate in social innovation processes in rural areas are also reflected in the results.

Keywords: rural development; territorial development; facilitators; social economy; LEADER; social relations; governance; networks; attitude; innovation policy

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1. Introduction

Social innovation (SI) is becoming increasingly important for tackling today's societal challenges, as a growing number of research studies have shown. Several authors consider it to be the new paradigm of innovation in the 21st century [1]. Public institutions have also embraced and value the benefits of SI to solve social problems as a complementary mechanism to the market and the state [2]. Nevertheless, the field is still not consolidated, and further research is needed to provide empirical evidence and contribute to the conceptualization of the phenomenon [3,4].

Despite the rapid growth of interest in SI, it remains an incipient research topic in the rural literature [5], whose use in rural development policies is ambiguous [6]. Among the issues concerning rural studies, there is considerable uncertainty about the role of the different types of actors involved in SI processes [7,8]. This is especially important in SI, where the subject of innovation resides precisely in the actors and their patterns of interaction [9].

A territorial approach is particularly necessary to address the role of actors in SI. The research conclusions on this issue obtained in urban environments cannot always be extrapolated to rural contexts. At the same time, rural territories are heterogeneous and undergo different territorial dynamics depending on their location, institutional environment, and participation in global socioeconomic processes [10]. This implies that the networks and roles of the actors involved in SI may vary according to the rural and regional context in question.

In order to address the aforementioned gap, this paper poses the following research question: *Which actors are involved in SI initiatives in rural territories and what role do they play in these processes?* The main theoretical contribution of this article is a better understanding of the actors involved in SI processes in rural areas, a topic that requires further attention in SI literature. To this aim, we propose an original analytical framework comprising three elements (scale, role and logic) based on primary data collected from rural initiatives developed in Spain and Scotland. By doing so, we introduce a comparative analysis of northern and southern European contexts, a rare perspective in SI studies in rural areas [4,11–13]. All this will support the definition of public policies that are better suited, not only to the particular nature of rural territories, but also to the characteristics of each SI initiative.

To provide an answer to this, Section 2 explains the role of SI in rural development and contextualizes it in relation to studies on leadership, governance, and the role of actors in SI. This is followed by Section 3, which presents the analytical framework, method and data used for the empirical phase of the research. Section 4 presents the study areas and SI case studies. Sections 5 and 6 present and discuss the results obtained in three case studies, respectively. Finally, Section 7 outlines the main contribution of this research in addition to the next steps that could be taken to deepen and broaden our knowledge of SI in rural areas.

2. Theoretical Background

2.1. Social Innovation and Rural Development

The notion of SI is not new. Schumpeter [14], Ogburn [15] or Polanyi [16], among others, have already referred to this concept more or less explicitly during the 20th century. However, the meaning of the notion has changed throughout history, according to the institutional context of each era and place [17]. In the 21st century, SI has been used interchangeably to refer, for instance, to new entrepreneurial solutions (models, processes, products, etc.) to social challenges and needs [18]; to new practices that affect social structures and the general well-being of the population [1]; or to the satisfaction of human needs through new social relations and empowerment processes [19].

Although it is accepted that SI is a phenomenon dependent on the territorial context [20], much of the literature neglects the particularities of rural areas. This gap has started to be bridged in recent years through the work of authors of rural tradition [5,9,21], where the understanding of the SI phenomenon finds several points of convergence. In general, it is conceived as a process (i) based on collective actions and transformations within social relations [9,22], (ii) where the main changes and outcomes occur on intangible elements [5,9,23], (iii) whose originality or novelty is relative to the context in which it is developed [23], and (iv) in which civil society is involved to different degrees [24,25]. In the present research, we gather these common points, and define SI as a process of reconfiguration of social relations between actors that leads to new forms of action in pursuit of collective goals, whose main result is the creation of social value [26].

We understand SI processes as those reconfigurations in social relations that occur in three dimensions: actor networks, attitudes, and governance arrangements [22]. SI initiatives can include new actors, new roles within existing networks, new values and motivations, and new coordination structures and mechanisms. SI transforms the way local actors interact in addition to how local communities connect and coordinate with external actors [27]. SI initiatives are identified as original and more efficient ways of social organization to achieve collective goals. They are processes recognized as innovative in their context and do not need to be replicable or scalable.

Some authors argue that rural societies are an appropriate context for SI, insofar as they represent small communities where more sociable and cohesive forms of life persist [23,28]. Simultaneously, there is some debate as to whether this is a process driven primarily by demands from the population to satisfy unmet social needs (demand-led), or by opportunities to generate new activities and improve the governance of rural territories (opportunity-driven) [28,29]. The different impulses and the actors' perception of the community's needs and opportunities determine, to a large extent, the intensity of SI and its transformative capacity [27].

Therefore, SI's contribution to rural development has multiple dimensions. On one hand, it is a means to find new and more effective solutions to traditional rural challenges, such as the lack of facilities and services [22,24,30]. On the other hand, SI is an end in itself that allows the reconnection of rural societies internally and externally. The first process refers to the incorporation of new groups of actors, mainly social and/or economic, in local development dynamics and the generation of social assets that improve the future performance of communities. Examples include greater social cohesion, sense of place or capacity-building [24,31].

Regarding the second process, rural territories benefit from the interactive nature of SI, associated with new social interactions that are not limited to the geographic area of the local community. During SI processes, actors from other territories are involved and different forms of coordination with organizations at different territorial scales are established [7,32]. This contributes to the articulation of rural communities with their socio-institutional environment (regional governments, firms, or third sector networks, etc.) and impacts their ability to access resources and their participation in decision-making processes [24]. Therefore, improved governance mechanisms adapted to the reality of these areas can be generated. The internal and external reconnection of rural actors are not only compatible, but complementary and necessary phenomena for the socioeconomic development of rural communities [33].

2.2. Key Actors in Social Innovation

In essence, SI is a process of innovation in social relations. It contributes to rural development by configuring new patterns of interaction between actors, whether these be individuals or organizations. Actors are the protagonists of reflexivity processes, through which they monitor the territorial context and deliberate about the activities and events that occur within it, with the aim of developing, implementing, and modifying ideas [34]. Actors also undertake preparatory actions, such as the construction and dissemination of narratives [35], in order to encourage a critical mass of individuals to participate and make the idea of innovation a reality [22]. Two aspects are relevant regarding the effective action of actors. Firstly, it depends on the agency or personal capacity to take action and transform the existing institutions and social system [36]. Secondly, agency is embedded in social structures and power relations that limit or encourage, to a greater or lesser extent, the possibilities to act and the scope of actions [34].

The role of actors is inherently linked to leadership. The leadership approach is interesting to address the missing link between the agential dimension of SI and how agents of change confront structural–contextual forces. Leadership is increasingly recognized in SI literature as a quality of groups, a view that challenges the conventional concept of leadership as individual leaders influencing followers [37–39]. Instead, leadership is a relational process in which actors are socially embedded [37]. While certain key individuals are often important, it is the production of collective capacities that contributes to democratizing SI initiatives and multiplying their effects [38]. Relational leadership in SI should be seen as a distributed practice of actors across sectors and scales that transform individual efforts into collective achievements [37,38]. However, there is not a set of practices or premises for effective leadership in SI. The specific conditions affecting a community or region determine the capacity for leadership to emerge and develop [40]. Leadership is composed of elements of physical, relational and emotional proximity, which provide shared vision and social legitimation in SI initiatives [41,42].

In rural areas, community leadership tends to be understood as inclusive, goal-driven and undertaken by a group of people that are willing to share power with others [43]. These groups of people can be configured by hybrid combinations of public and private actors. However, civil society usually plays a leading role in rural SI. In rural territories, this fact is of particular interest, to the extent that they are recognized as places where the presence of conventional innovation actors (universities, technological institutes, and companies) is lower, and where the agglomeration factor (a determining factor for creative processes and spill-overs) is replaced by low population densities [44]. Thus, civil society self-organization and networks with actors outside the territory are recognized as defining elements of SI in rural areas [24,25,32,45]. These features can be clearly linked to the quadruple helix model [46].

Almost by definition, the leading role of civil society is also attributed to the leadership of social economy (SE) entities. Anglo-Saxon studies describe social enterprises as promoters of SI initiatives, mainly because they are enterprises whose social and collective objectives are more important than economic ones and, therefore, they continuously pursue new solutions to meet social needs [28,47]. From the European SE tradition, these entities are also significant for SI because they incorporate participatory and inclusive processes in their performance and can, therefore, promote new social relations and the empowerment of new social groups linked to their activities [48,49]. For example, the SI-DRIVE project shows that NGOs or non-profit organizations are the leading actor in almost 50% of the over 1000 SI initiatives examined [50].

In the rural literature, the connection between SE and SI is still underexplored. In the Anglo-Saxon context, recent studies highlight that the importance of social enterprises in SI processes is due to their capacity to integrate material and immaterial aspects of their rural environment, to combine economic and social relations, and to act as intermediaries between the rural community and key actors outside the territory [51,52]. In Spain, these relationships have been especially explored in southern regions, where the role of agricultural cooperatives in activating SI processes and combating depopulation has been demonstrated [53,54].

SI goes beyond the leadership of civil society. The nature of this phenomenon requires cross-sectoral interactions at different scales [9,50]. The public sector is one of the actors that explain this hybrid character of SI. Its role is usually described as complementary to that of civil society, providing funding, networking support or legal frameworks for the emergence and development of innovations [50,55]. This very function of the public sector is usually emphasized in local development studies [56,57].

Many SI initiatives establish multi-level governance mechanisms with public organizations that enable them to be effective and scalable. This reflects the interactive dynamic necessary for neo-endogenous rural development, combining bottom-up/top-down and endogenous/exogenous processes [23]. The interactive nature of SI led some authors to conceptualize *bottom-linked governance* or *bottom-linked SI* as novel forms of cooperative and democratic governance between civil society and public sector across different scales [58]. The concept is important to link SI initiatives with broader socio-political changes and to stress those processes enhanced by the public sector [59]. Bottom-linked governance can be an outcome of SI processes when social reconfigurations generate new combinations of actors, resources, functions and coordination instruments. Additionally, bottom-linked governance is key for SI durability because it facilitates flexible and inclusive spaces for new collective actions [59,60].

Nonetheless, the involvement of the public sector in SI and bottom-linked governance mechanisms is complex. Copus et al. [30] explain that this depends on the role that governments have historically played in each community, the prevailing welfare regime in the region or country, and the greater or lesser degree of decentralization existing in the prevailing forms of territorial governance. For example, recent research in Nordic rural areas identifies that the civil society–public sector pairing is the most relevant combination of actors in the early stages of SI and that the public sector is especially involved in SI initiatives related to the provision of social services [7]. Other authors note that the public sector should play a strategic role in revitalizing latent rural communities, as a source of inspiration and networking [46], in addition to contributing to improving territorial conditions for SI in those rural areas most weakened by their remote conditions and/or the impact of austerity policies [24,61]. However, there is also evidence—albeit limited—that the public sector can lead SI processes in rural territories, such as described by Franklin et al. [62] in the field of community food growing initiatives in Hungary.

While examining the role of the public sector in rural SI, allusions to the role of LEADER and Local Action Groups (LAGs) are also frequent. SI is one of the defining characteristics of the LEADER[1] method since its implementation in the late 1990s [63–65], although it is not explicitly referred to until much later [66]. The capacity of the LEADER method to promote SI lies in the fact that its design pursues the formation of new cross-sectoral networks, bottom-up processes, public–private partnerships, and cooperation dynamics, which is directly linked to the emergence of new ideas and new social relations [67–70]. For instance, Dargan and Shucksmith [71], based on an extensive analysis of LEADER projects in different European rural contexts, concluded that the practical experience of rural development policies is mainly associated with the generation of local connections, collective learning processes and the improvement of the rural milieu [71]. Yet, other studies show that the practical implementation of LEADER does not always allow the full socially innovative potential of the method to be realized due the excessive bureaucratization, the tendency to prioritize low-risk projects and the existence of clientelist networks [72,73].

Thus, there are still many gaps in the literature about the role of the different actors in SI processes in rural areas. The theoretical role of civil society tends to be over-represented, while that of the public sector is controversial. Furthermore, the role of LEADER and the social economy in SI in rural contexts remains little explored.

3. Materials and Methods

3.1. Analytical Framework for Social Innovation Actors

The study of SI in rural areas faces the challenge of a diversity of dimensions and actors involved in this type of initiative. It is necessary to design an analytical framework that allows for an operational categorization of the complexity associated with SI. Based on the literature reviewed in the previous section, we present the following three analytical dimensions that guide our empirical research on the role of actors in SI processes: logics, roles, and scales (Figure 1).

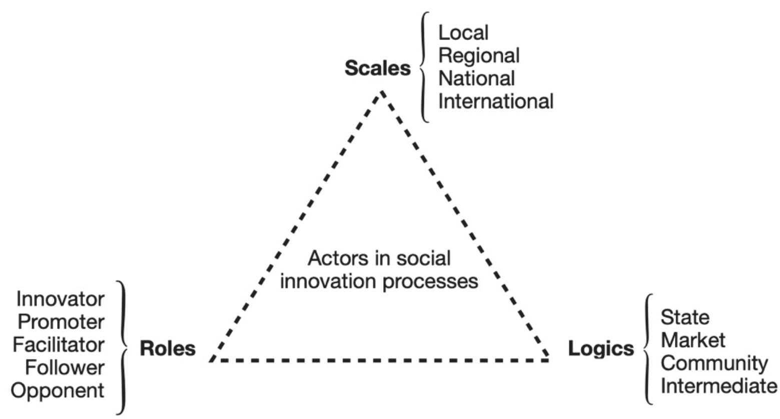

Figure 1. Analytical framework for social innovation actors. Own elaboration.

Avelino and Wittmayer [74] suggest a model based on the multi-actor perspective, where the interests that define the performance of actors in SI are grouped under four logics: (i) state logic, rooted in non-profit, formal relationships that pursue the general interest (e.g., administrations and public bodies); (ii) market logic, structured in profit-making, formal relationships motivated by private and particular interests (e.g., capitalist and commercial companies); (iii) community logic, defined by non-profit, informal relationships that meet a combination of individual and group interests (e.g., households and families); (iv) intermediate logic, represented by actors that by nature interact between the three previous logics, depending on each particular process (e.g., social economy and third sector entities).

In addition to the logics or interests that drive the actors' actions, they can also adopt specific roles according to their participation in different phases or activities of SI. Drawing on innovation and territorial development literature [21,46,60,61], we have elaborated on the original terminology for the role of actors in SI. *Innovators* are those actors who formulate a novel idea or import it from outside, even if it is not necessarily feasible at the time it is proposed [22]. Among the qualities of innovators is their ability to take risks and embark on unusual actions in their territorial environment [75]. *Promoters* may play a leading role in the dissemination of the idea, but they are especially responsible for its implementation. *Facilitating* actors assume the role of generating the conditions for actors to reflect, decide, interact, and take action [76]. This figure is similar to the one described by Rogers [75] regarding the *change agent*, whose role is to persuade and guarantee the adoption of the innovation. Moreover, this role is often associated with public actors [55]. *Followers* embrace the idea and join the initiative, for example, as users of an activity, beneficiaries, or simple collaborators [22,75]. Finally, *opponents* resist the idea of innovation somewhat explicitly, or try to block or redirect it during its development. This can occur when some actors may be affected as the innovation gives an impetus to other members of the system to adopt it, widening a socio-economic gap over the opponents [75]. The presence of opponents is especially likely in radical SI processes [27].

A third dimension in which SI actors operate is the territorial scale. SIs can combine actors at local (infra-municipal, municipal, or county), regional, national and international scales.

3.2. Data Collection and Qualitative Analysis

The previous analytical framework allows us to address the empirical dimension of the research through a mapping of SI actors in rural areas and the identification of their logics, roles, and territorial scales. This approach is applied to three case studies from Spain and Scotland. The case study method enables the examination of each innovation process in its particular context [77] and, at the same time, the cross-case approach helps to build more generalizable insights [78]. The latter is important since it also contributes to a better understanding of the influence of different institutional settings on actors' involvement in SI and to a comparative analysis between rural areas in Northern and Southern Europe.

The fieldwork was undertaken in two rural areas located in remote and intermediate regions, with a well-defined geographical scope: the parish of Birse (northeast Scotland, UK) and Ibiza–Formentera (Balearic Islands, eastern Spain). This choice was justified by the importance of collecting different socioeconomic and institutional conditions. In each area, the selected case studies met four basic criteria: (i) initiatives perceived by local actors as novel and innovative in their local context, (ii) with the potential to improve the well-being and sustainable development of rural communities; (iii) develop in different fields of rural development (diversity of initiatives); and (iv) some value/richness in the available information was detected in advance [79]. The case studies are related to new forms of land ownership and forestry (Birse Community Trust, BCT), new forms of natural resource management in the face of socio-environmental conflicts (Alianza Mar Blava, AMB), and processes of agricultural revitalization and preservation of the rural landscape (Cooperativa del Camp, CC).

The primary data were collected through fieldwork between 2017 and 2018. The main qualitative technique used in data collection was semi-structured interviews with key informants, previously detected and purposely selected [80]. This technique was supplemented by participant observation and documentary analysis of the three initiatives. A total of 33 interviews were conducted (15 in AMB, 13 in CC and 5 in BCT). The variation in the number of interviews reflects the different volume of actors involved in each initiative. In the BCT case, the information available through secondary sources was very rich, which made it possible to reduce the number of interviews and focus their content on very specific aspects related to the perceptions of key actors, in addition to latent tensions within the community.

The interviews, lasting between 60 and 90 min, aimed to identify the network of actors involved in the initiative, their main characteristics, and their role throughout the process. These questions were followed by other queries to contextualize the SI initiative, e.g., what factors promoted the emergence of the innovation, the main changes perceived in the networks, the attitudes and forms of coordination, and the main practices developed. All interviews were recorded with the consent of the interviewees and subsequently transcribed using F5 v.7.0.1 (2018) software, F5, Inc. (Seattle, WA, USA).

Participant observation was developed through the researchers' presence at board meetings (in all case studies) and participation in socio-cultural events (BCT). This method allowed for a better understanding of the social settings in which SI initiatives take place [81], faithfully capturing the reality of the interactions between actors and then contrasting it with the discourses collected in the interviews. A field diary was used to collect the researchers' own perceptions of the activities in which they were present, in addition to photographic material.

The secondary information gathered allowed us to identify actors involved in SI processes prior to the interviews and, in some cases, to complement the information from the ex-post interviews. This information also enabled us to improve our understanding of the study area, in addition to the historical perspective in which each case study was embedded. For all cases, information from social media and local press was used. In the particular case of AMB, we also relied on several reports available on the association's website[2]. Through the BCT[3] website we also had access to meetings' minutes and newsletters from the beginning of the innovation process, in addition to multiple annual strategies, territorial data and reports illustrating the role of various actors over time.

The analytical process of the research was based on the triangulation of information generated from documentary analysis in combination with the analysis of semi-structured interviews and participant observation data [82]. All data were examined using the technique of qualitative content analysis. Through this process, firstly, a deductive thematic organization of the data was derived in accordance with our analytical framework. Secondly, an inductive process was followed with new sub-categories closer to each case study, which are reflected in the results and discussion section. The qualitative analysis was conducted using MAXQDA 2018 software [83].

4. Description of Study Areas and Social Innovation Initiatives

The SI initiatives selected for this study are innovative in their context. They illustrate processes in which new social relations are created and sustainable development is promoted. Despite the fact that some of the examples are difficult to replicate, they help us to understand the social and intangible dimensions of contemporary rural development processes in Europe. In this section, we present the case studies and study areas of the research, and underline the SI component of each example.

4.1. Birse Community Trust and the Parish of Birse

The parish of Birse is located in Aberdeenshire (Scotland, UK), a forest area with fewer than 800 inhabitants and 6 inhabitants/km^2. While this territory has poor accessibility and weak access to services, it is relatively strong in terms of employment and household income thanks to its proximity to Aberdeen (44 km) and the impact of the oil and gas industry. The case study we examined (BCT) emerged as a response to the different needs faced by this area, such as the weakness of local governance systems in Scotland, the high concentration of land ownership in a few families, and the abandonment of local assets linked to the natural heritage of the community. The initiative also capitalized on opportunities, such as the high dynamism of the community, the new funding linked to the development trust model in the United Kingdom, the high ecological and cultural value of the area, or the Scottish policy framework that allows local communities access to land and forest ownership (Land Reform (Scotland) Act 2003).

BCT was triggered by the rediscovery of ancient community rights on the use of the Forest of Birse. After three years of negotiation with estates, in 1998, the rights were transferred to a community body (BCT) owned by every inhabitant of the parish. Since then, BCT has been managing several forests and assets of local interest. The process has promoted a more equitable distribution and social use of the land, a reconnection with the natural environment, an improved local governance system, a new role of civil society in local decision making, stronger relations with public organizations, and learning in the management of socio-economic projects.

4.2. Alianza Mar Blava and Ibiza-Formentera

AMB takes place in Ibiza and Formentera (Balearic Islands, Spain). They represent an integrated area formed by two islands (LEADER area). In total, they have more than 100,000 inhabitants and 150 inhabitants/km^2. The islands are defined as rural and intermediate areas under urban pressure, where the economy is based on tourism (40–50% of GDP). The ecological relevance of the environment and landscape is the main tourist attraction. At the same time, the social climate between tourism businessmen and environmental organizations is in conflict, due to their different interests in the territory.

This initiative originated as a response to several oil prospecting projects in the Balearic Sea promoted by international companies and the national government. Despite the complexity, there was an unusual common position among local community actors against the projects. A new association (AMB) was set up, and a new network representative of the local community was constructed. The process involved novel social reconfigurations, such as collaboration between previously confronted actors (business and environmental actors), a new shared vision of the natural environment and of personal and human relations, and a new discourse on sustainability among business actors. Through administrative actions, pressure and social protest it was possible to stop a large part of the hydrocarbon projects. The social learning processes identified include new mechanisms of marine governance and replication at the local level.

4.3. Cooperativa del Camp and Formentera

Formentera is the smaller island of the Ibiza–Formentera area, with fewer than 12,000 inhabitants and 100 inhabitants/km^2. It is defined as a remote area, where more than half of the population lives in scattered settlements. The progressive abandonment of agriculture since the growth of tourism during the 1960s is one of the main challenges faced by this territory. CC was triggered by two processes: (i) the risk of loss of assets of the former cooperative due to inactivity, and (ii) a political interest in reactivating local agriculture and recovering rural landscape. The SI elements in this process included the creation of a new agricultural cooperative (CC) as an agent for the development and coordination of the agricultural sector. A strong public–cooperative coordination was developed and the rural values of the population reinforced. Likewise, civil society was engaged through the *Cens de Terres*, a mechanism for transferring land from local landowners to the cooperative in order to be cultivated and prevent land abandonment.

5. Results

In this section we outline the role of the main actors involved in each of the three case studies. Figures A1–A3 detail the actors and summarize their main functions according to the three dimensions of our analytical framework (roles, logics, and scales). Roles are represented by symbols, the four logics are illustrated by four axes, and the different territorial scales are drawn by using circles and different color ranges. When actors hold more than one role, different symbols are included. The figures allow us to quickly visualize the number and diversity of key actors involved in each initiative, the scale at which they operate, the role/s they play, and the logic they adhere to. Additionally, the figures show the links and functions between actors. Weak links or relationships (dotted line) are depicted as those described in the interviews which could not be fully corroborated through the research.

5.1. Birse Community Trust (Aberdeenshire, Scotland)

5.1.1. Initial Promoters and Key Innovator

The innovation process at Birse Community Trust (BCT) bought together mainly members of the local community, in particular the innovator, the new BCT management team and, more broadly, the rest of civil society (see Figure A1). The process of negotiating the ancient rights and the formation of BCT was an intense phase in the process of defining and implementing the SI. A total of six people represented the three parties involved during the initial negotiations: two representatives of the two estates (market logic) and four representatives of the local community and civil society (community logic). The latter four actors represented the real promoters of the project in the initial phase. They were mostly people involved in local organizations—community associations—and interested in recovering new uses for the natural environment of Birse. Among them, all the interviewees highlighted one person in particular, BCT_04, who, in addition to being the promoting force, was considered to be the innovator of the initiative.

BCT_04 was described in the interviews as a person who is passionate about community issues. After over 25 years of research into the history of the parish, this individual was the one who re-discovered and disseminated the community's ancient rights over the Birse Forest. Professional experience in rural development meant that this person was aware of local needs, of new approaches to development—such as community ownership— and of opportunities for his community—such as those linked to the development trust in the United Kingdom in the 1990s:

> "There was a realization in Finzean Community Association that, as a community, if you were not doing things for yourself, nobody else was doing them, and that the community needed a new vehicle to be able to do that. The particular issues at hand were the ancient rights over the Forest of Birse, and the watermills in Finzean [...] Birse Community Trust was set up as a vehicle to save those things [...] I was aware about all these things. I didn't want to do it, but the opportunities were just irresistible [...] When BCT started we decided that it would not raise money locally, because that would take money away from the other community bodies, and it would not use voluntary labor from other organizations but pay local people." (BCT_04_innovator)

BCT_04 was the main actor in the design of the new community organization, to which ancient rights were to be transferred, and also in the conceptualization of its functioning in the service of local community development. BCT_04 was the manager of BCT for a short period of time and an advisor to the board of trustees for almost 20 years. In addition to this knowledge of Birse Parish and rural development, this actor had strong personal networks with public institutions and landowning families and drew on them to support the initiative and raise funds.

5.1.2. Between Promoters and Opponents: The Shaping of a New Board and Potential Socio-Political Conflicts

The BCT's management board was the core of the initiative's promoters during its development and consolidation phase. It mainly consisted of a group of trustees, a chair, a patron, and a manager. While BCT is a community enterprise that pursues the common good and its members follow a community logic, the members of the board are also individuals with particular interests and, at times, their own agenda. In May 2018—shortly before the fieldwork of this research—some key positions on the board of trustees, such as the chair and management, were renewed. The community logic underlying their actions is clearly stated in the following quote:

> “I think the natural heritage it’s a big one for me. The area would not look the same, or feel the same, without the work that we’ve done. I’m talking about the Forest of Birse, and our commercial forests. I think those are hugely beneficial. Our historic buildings, they would have fallen into the river by now.” (BCT_03_BCT trustee)

> “I would say I live on two acres of woodland, planted and managed for sustainable reasons and diversity, surrounded by likeminded people [...] I describe it by what’s immediate to me and the people around me participating in BCT.” (BCT_06_BCT trustee)

Interviews with several of these new members revealed a critical narrative on the role of the innovator (BCT_04). The main axes of tension related to a less than inclusive leadership style, differing perceptions of the role of the community, the nature of relations between BCT and large landowners, and the desirable degree of civil society participation in BCT.

The latent conflict between members of the new board team and the innovator was due to ideological and political differences, partly linked to the social structure of the territory. While the innovator was linked to nationalist movements in favor of Scottish independence and was involved in the preparation of the Land Reform Bill, several members of the new team were close to large land-owning families in Birse Parish, in addition to national hunting organizations. These prospects tended to align politically with the center-right Unionist and Conservative Party, which is against Scottish independence.

5.1.3. Followers: The Growing Involvement of Civil Society in the Parish

Despite the existing tensions, the promoters and key innovator of this initiative responded, in essence, to a combination of individual and collective well-being interests (community logic). The remaining members of the civil society of Birse Parish, who were part of the organization only by virtue of the fact that they lived in the area in question, were integrated with the same logic. With the formation of BCT, a coordination structure was established for the first time to enable effective participation of the local population in the decision-making process regarding the management and ownership of various local forests and assets, in addition to proposing new projects that addressed the needs and opportunities of the territory. For example, in the participatory process for the last acquisition of a forest in 2008, more than 600 people voted, 75% of the census. However, direct and regular participation in decision-making was mainly concentrated in the members of the management board. Hence, most other members of the local civil society adopted the role of followers.

5.1.4. Between Supporters and Opponents: BCT’s Controversial Relationship with Estates

Over the last few decades, three estates have accumulated 90% of the land in the parish: Finzean, Birse and Ballogie. These actors were market-driven and had local origins. The relationship between the local community—represented through BCT—and the three estates was controversial and there was no common narrative among interviewees. On the one hand, some members of the new BCT team explained that the landowners felt threatened by the possible interest of BCT, and BCT_04 particularly, in taking their properties. These were the same individuals who reported tensions with BCT_04 within the community (see Section 5.1.2).

Nevertheless, another segment of the interviewees maintained a different narrative. The innovator (BCT_04) argued that BCT, and themselves, managed to reach agreements with the three estates on different occasions, for instance, the transfer of the ancient rights over the Birse Forest and the acquisition of several cultural assets that BCT managed. Other interviewees who were not on the board supported this account, although they also explained that each estate’s relationship with the local community was different. For example, Finzean estate was described as an actor close to civil society and contributing to the improvement of their living conditions—and to the very shaping of BCT—while

Ballogie estate accumulated a greater number of disputes and confrontations with members of the local community.

5.1.5. The Public Sector as Facilitating Actor

The role of the public sector in this initiative focused on being the legal umbrella for the acquisition of forestry assets, in addition to its occasional presence in certain phases and activities. In this sense, the role of the Forestry Commission Scotland (FCS), the most important public organization that until 2019[4] was in charge of the country's forestry affairs and owned numerous forests, should be highlighted. This entity was important in the acquisition of two forests by the BCT. In addition to financial support, it was also involved in several local governance mechanisms in the forestry field. In financial terms, LEADER[5] was also involved in some specific projects, but with little visible role for the local population and its own group of promoters.

The role of the public sector in this initiative must also be examined from a broader perspective, considering the national government itself and its role in designing an institutional framework that, in part, facilitated the existence of BCT. On one hand, the emergence of BCT was clearly related to the introduction of development trusts in the 1990s, as organizations devoted to promoting initiatives for local development led by civil society. In the context of the United Kingdom, these entities are owned and managed by the local community, they pursue sustainable community development, and are non-profit, independent, and usually seek to generate their own income through the ownership of assets that are invested in local projects [84].

Moreover, the legal instruments opened up by the Land Reform (Scotland) Act 2003 [85] are fundamental for the development and consolidation of BCT, in particular for the acquisition of woodlands (Balfour and Slewdrum). This reform was aimed at reducing the constraints that the high concentration of land ownership in Scotland placed on the sustainable development of rural communities. Under the Act, local communities are given the "community right to buy", meaning that they have the opportunity to purchase land in their geographical area, subject to specific organizational and planning requirements. This Act has undergone several amendments that have continued the process of land reform in Scotland. The latest law in this regard is the Land Reform (Scotland) Act 2016 [86], which was recently revised in April 2020. The latter modification, as a new development, allows local communities to exercise an absolute right to buy if they can justify a contribution to sustainable development, that is, they can justify the importance of recovering an asset and force its sale even if the owner does not envisage transferring ownership.

5.2. Alianza Mar Blava (Ibiza-Formentera, Spain)

Alianza Mar Blava (AMB) was created in May 2013 with the aim of bringing together the societies of Ibiza and Formentera in order to paralyze hydrocarbon projects that threaten the natural environment, one of the most important tourist resources of the territory. The main network of promoters was configured around a working group initially made up of 14 people, a number that varied as the process evolved. This group was made up of representatives of local businesses, environmental and public institutions—market, intermediate and state logic, respectively—and its members were responsible for the daily management of the alliance's activities (see Figure A2).

5.2.1. Ibiza Preservation Fund: Combining the Role of Innovator, Facilitator and Promoter

There was an actor in the environmental sphere that played a strategic role in the emergence of Alianza Mar Blava: the Ibiza Preservation Fund (IPF). This is a philanthropic organization of Anglo-Saxon origin with a presence in Ibiza and Formentera, whose objective is the environmental conservation of the islands and the promotion of sustainable development projects. The person who directs this organization (AMB_01) performs a prominent role as an innovator, facilitator, and promoter of AMB. All interviewees recognize the central role of this individual in identifying opportunities around the issue of prospecting and the initial diffusion of the idea of innovation (acting collectively against the external threat). IPF was key in building the initial network of promoters, in funding the first actions and in the development of AMB itself up to the present day.

The participation of AMB_01 was defined by a series of qualities that enabled us to identify the importance of the actions taken to facilitate the SI process. These qualities included a high level of training and experience in local development and social articulation processes. AMB_01 exerted a leadership role within the organization, through which, despite the negative expectations surrounding the prospecting, this individual was able to convince different actors in the initial stages, built bridges between different social groups (environmentalists and businessmen), and connected local organizations with other actors outside the territory (e.g., international NGOs). Furthermore, they demonstrated a strategic vision of the territory insofar as they fostered new capacities in local actors to solve future challenges, beyond the problem of prospecting (e.g., renewable energy projects):

> "The strategy I follow is promoting new alliances and new contacts between projects because people here usually work too isolated. I identify emerging needs and look for new opportunities [...] Normally, economic and environmental interests are always the exact opposite here. But at the time I realized that everyone was moving in the same direction [...] People were worried, but there was no project. In the end it was a matter of holding these meetings [...] I could clearly see that to form an alliance, we all had to be in on it. I went to introduce myself to those I didn't know [...] first we started showing a lot of respect, explaining why this made sense [...] we are all going to build it right from scratch [...] not moving with something vertical was most interesting." (AMB_01_Key facilitator)

5.2.2. The Convergence of Environmental Organizations and the Tourism Industry as the Promoting Force behind Alianza Mar Blava

In addition to IPF, the other environmental organizations also played a fundamental role in the implementation and development of AMB. They combined local entities with others integrated in international networks, with different activist profiles, all of which respond to the parameters of the social economy. They were the promoting force behind the initiative from the outset to the extent that they assumed responsibilities during the life of the initiative. Their role in AMB was essential to involve the citizens of Ibiza and Formentera. In addition, their knowledge of the natural environment was critical to the development process, for instance, in the dissemination of the conflict or the creation of narratives on sustainability.

As for the business sector, it was represented in the AMB by two of the most powerful business organizations in the territory. Both organizations were local but were integrated in their respective networks at regional and national levels. Their interest in AMB was associated with the preservation of tourism activity on the islands, something that the hydrocarbon projects put at risk. Thus, their involvement in the initiative clearly responded to a market logic. The representation of the business sector in the work team was limited in quantitative terms. However, all interviewees recognized their prominent role as promoters of AMB. These organizations assumed positions of responsibility in the association and were protagonists of one of the main social reconfigurations taking place in the framework of this SI process: the convergence between environmental and business actors.

Indeed, environmentalists and tourism industry constituted two traditionally antagonistic interest groups in the territory with a long history of conflicts, including legal ones. As a consequence of the hydrocarbon conflict and the creation of the AMB, they became, for the first time, part of the same network and collaborated in different practices. The complexity of this interaction explains why the design of AMB governance was one of the most important aspects for the actors of the initiative and, in fact, a defining element of this SI. AMB is an association with a balanced representation from the social (environmentalists), business and institutional spheres. Therefore, for instance, it was decided to establish a small working group with three representatives from each of these sectors, two of whom acted as spokespersons on a rotating basis. In this group—and in the larger working group—decisions were taken by consensus.

IPF, as the main facilitating actor, played a prominent role in the design and control of these coordination mechanisms and avoided the predominance of individual leadership from any of the groups of actors, including its own. Along these lines, several interviewees indicated that the profile of the IPF—an environmental organization recently established in the territory—was perceived as more neutral than the rest of the local actors and, therefore, contributed to the necessary support during the early stages of the innovation process. For this reason, if the initial impulse of the process had been led, for example, by a town council or an environmental organization with a long history in Ibiza and Formentera, it would have been difficult to create such a broad network of actors in such a short time:

> "If this project had been started by the GEN or Amics de la Terra, the traditional environmental organizations on the island, it would have generated mistrust because they have a label [...] People did not know us. We are a foundation from outside the island. We did not have an agenda and did not seek visibility." (AMB_01_Key facilitator)

5.2.3. Promotion and Facilitation of the Process by Public Institutions

The initial promoters of the process promoted the involvement of public administrations of the territory in the AMB, mainly town councils and island governments (local level). The participation of this type of actors was carried out through environmental practitioners of the institutions, but not through people with political responsibilities. This decision was intended to avoid possible conflicts and strategies in the field of local politics, and thus to facilitate the adhesion of those local administrations governed by the same party that formed the central government, against which action was intended to be taken. This measure also helped to show the alliance as an initiative of a cohesive community without internal tensions, which favored its role towards the central administration and the oil companies.

The leading participation of practitioners situated politicians as followers who supported the initiative, but without a prominent role in its functioning. Environmental practitioners, on the other hand, were the real promoters of AMB from the public sector. They also acted as intermediaries between the actors promoting the alliance and the political actors, being in charge of convincing them of the seriousness of the threat and the need to join in a collective action. Thanks to the facilitating role of the environmental practitioners, the financial support of the public sector was secured, thus making the economic sustainability of the initiative possible. Public administrations are also strategic in administrative–legal practices, such as the allegations presented in the concession files of hydrocarbon projects and environmental impact assessments:

> "The Consell [island government] played a key role at the supra-municipal level. We made a great allegation against the prospecting projects [...] We had technical capacity and led that process. Then, local councils adapted our allegation to developed their own ones." (AMB_12_Environmental technician in Consell of Ibiza)

> "We knew that local administrations had to respond to these projects. If there had been only a reaction from social organizations, it would have not raised the same attention. We, as a local administration, had more capacity to suspend those operations." (AMB_11. Environmental technician from a local council)

5.2.4. On Promoters from outside the Territory and Other Followers

Among the non-local actors involved in the AMB, it is worth mentioning the strategic role of technical profiles linked to international NGOs (Greenpeace) and Spanish consultancy firms (Salvia). These actors adopted a role that could be defined as a promoting force, to the extent that they performed some of the most crucial actions of the initiative, including lobbying national and European bodies, and preparing technical studies. IPF networks, as a facilitating actor, were essential for the insertion of this expertise of other national and international NGOs into the local community.

Finally, AMB brought together a large number of organizations from various sectors—more than 100—in addition to independent individuals. Most of these actors supported the initiative, but their level of participation was relatively low. Within this type of followers, it is necessary to highlight the role of two local citizens' platforms (Eivissa Diu No and Plataforma Anti-Petrolífera), which emerged directly linked to the conflict under a strictly civil (community) logic. Their refusal to cooperate with the business sector prevented their inclusion in the association's working group; however, they did join as AMB supporters. They played a militant and activist role, complementing the more institutional nature of AMB. Nevertheless, after the first successes of the initiative, with the reduction of the climate of social conflict and the beginning of a more bureaucratic phase of work, the relevance of the citizens' platforms was drastically diluted.

5.3. Cooperativa del Camp (Formentera, Spain)

5.3.1. Leadership of the Local Government

The island government—*Consell de Formentera*/Formentera Council—plays a leading role in CC. The *Consell* is governed by a local party established in 2007 (Gent per Formentera—GxF), with a nationalist and green left-wing profile. Its electoral program is committed to the revitalization of the agricultural sector through a new cooperative and the recovery of Formentera's rural landscape, not only as an input for tourism, but also as a defining element of the island's culture and territorial identity.

The *Consell* performed a triple role: facilitator, innovator, and promoter (see Figure A3). The role of facilitator was justified by its function of mobilizing the actors who led the first management board of the new cooperative and accompanied the administrative–legal process. For this purpose, he appealed to descendants of the former members, in addition to members of the only local agricultural association (Associació de Ramaders) and other individuals interested in agriculture. The *Consell* was also the main financial sponsor of CC and was the institution that encouraged the articulation of mechanisms for regular coordination between the cooperative and the public sector.

The *Consell* demonstrated a capacity for innovation. The political representatives of this administration were able to channel the concerns of the local population and design together with other promoters, projects of great originality in the territorial context of the study, such as the *Cens de Terres*. Its SI was a novel coordination mechanism by which civil society, in general, could transfer their land to the cooperative to be cultivated free of charge for periods of three, five or ten years.

One of the factors that explains the *Consell*'s capacity for innovation was its singular institutional configuration. In 2007, Formentera eliminated its municipal administrations and grouped them under a sole uni-municipal entity. The *Consell Insular de Formentera*—located between the regional and municipal levels—assumed the administrative functions of the municipality but maintained a single government with insular status. This political-administrative peculiarity of the island of Formentera gives the territory a wide range of powers and, therefore, a greater capacity to design public policies than other rural local governments [87].

Lastly, the *Consell* was also a catalyst for the initiative due to its involvement in the development of the cooperative's activities. This implication is reflected in the intense coordination between the *Consell* itself and the cooperative, one of the most notable elements of innovation in CC. Through this coordination, the *Consell* addressed the needs of the cooperative and the agricultural sector and aligned them with other public projects in the area. The rationale behind this actor's participation is illustrated in the following statement:

> "We live quite well because we earn a lot of money in summer [...] but we need to value our traditional environment. If you go to the beach and you see a nice rural

> landscape, I think that's good for everyone [...] the primary sector makes us better as a community [...] in the past we were an extremely poor island [...] local people knew how to make a boat, a house, cultivate, manage a forest or the slaughter of cattle [...] we want to recover and diffuse this know-how to young people because tourism tends to standardize territories." (CAMP_01_Representative of the local government)

5.3.2. The Cooperative's Management Board: The Core of the Promoting Force

The other CC promoters were people from the cooperative's management board. A number of these actors also proposed new projects for the development of the cooperative and could, therefore, be described as innovators. They were all men and residents of the island, and the majority were aged between 46 and 60 years. They had different levels of education, from university to elementary education, and their professional background was also heterogeneous—only two members were specialized in agriculture. The core group of promoters participated in CC mainly under the logic of the social economy. Their motivations combined the desire to contribute to the reactivation of agriculture through collective entrepreneurship formulas (cooperatives), to satisfying shared emotional needs (for example, to avoid the abandonment of the fields) and, to a lesser extent, to achieving particular economic benefits (to obtain agricultural services at a lower price than the existing ones).

5.3.3. Civic Society Participation through the Cens de Terres

An essential element of the actor network in CC was represented by small landowners. In Formentera, local families frequently have agricultural plots, although few actually farm them. The *Cens de Terres* was the main instrument that connected these small landowners, and civil society in a broader sense, with the cooperative. Most of the people who transferred land were inhabitants who were descendants of families with strong family roots on the island. They were individuals who sought to recover Formentera's agricultural land, but due to their age or occupation, were unable to work them:

> "I am really interested in everything implying taking care of our land [...] This was my parents' land. I do not want to sell it to anyone. I would be very grateful if the cooperative cultivates it because my children will not do it." (CAMP_04_User of Cens de Terres and member of the cooperative)

> "I do not have enough time to work my land [...] that is why I transferred my plot to the cooperative, to see it alive and nice. In some way, this is the island's garden [...] I have been subjected to pressure from people who wanted to buy my land, but real estate is not the idea of investment I have." (CAMP_08_User of Cens de Terres and member of the cooperative)

The cooperative represented the central structure that enabled achievement of the involvement of civil society. It is a collective enterprise with a historical tradition on the island, rooted in the imagination of many families and, in principle, detached from political interests. The participation of small local landowners through the *Cens de Terres* and the cooperative introduced a community logic into the SI process, made possible a public–citizen coordination and, ultimately, increased the role of civil society in the rural development of Formentera.

5.3.4. Other Actors

Apart from the local government, the cooperative's management board and the landowners who participated in the Cens de Terres, there were not many other actors involved in CC. One of the actors that raised some interest was an agricultural practitioner, external to the territory, who was hired by the cooperative to lead several agricultural tasks (promoting role). This actor contributed to improving the limited agricultural knowledge of the cooperative members, bringing new ideas, and also had an essential part in guiding the action of the public sector in this field (e.g., he was also the practitioner in charge of implementing a new public project on irrigation).

Finally, a further actor involved in CC was the LAG-LEADER Ibiza-Formentera. Its main function was to finance a substantial part of the cooperative's new assets (promoting role). Notwithstanding, the LAG's technical team did not entirely agree with two aspects of this initiative. On the one hand, a risk was seen in the financial dependence of the cooperative on the local government. On the other hand, it considered that the central role in the agricultural development of the territory should not only be played by the new cooperative, but also by a greater number of initiatives of individual and collective entrepreneurship.

6. Discussion

Several insights can be obtained from the results that contribute to the existing debate on the role of actors in SI processes in rural areas. In the following section, the role of local and non-local actors, the role of facilitating and neutral actors, of the social economy, of the public sector, and finally of LEADER and LAGs, are discussed.

6.1. The Scale of Actors: SI as Local Processes

The case studies in this research include changes in the relationships between actors at different territorial scales and reflect the bottom-linked character of SI [4,23]. For the main exogenous elements, the focus is on external actors with facilitating roles linked to the provision of funding, knowledge, or legal instruments. In CC, for instance, knowledge inputs were received which were justified by the scarce agricultural know-how of the new generations of Formentera and the current development model, centered on tourism. In AMB, the exogenous impulse was more powerful, as local actors required external experts capable of exercising a lobby function in national and international bodies in order to stop oil prospecting projects. Similarly, in BCT, public funding and the legal framework of the land reform were elements introduced by actors from outside the territory, which played a strategic role in the initiative.

Nevertheless, it is necessary to remark that all the innovation processes analyzed here were mainly driven by local community actors (bottom-up) and relied, in essence, on endogenous or place-based resources (e.g., forests, cultural and natural heritage, agricultural tradition, landscape, marine environment, etc.). Although actors from outside the territory contributed to consolidating SI initiatives, they did not represent the most prominent component in terms of innovation in social relations. For instance, in AMB, the most intense SI dimension lay in new business attitudes or new forms of coordination between tourism industry and environmentalists, all of which were generated within the local community. Even in the case of BCT, where the exogenous impulse was irreplaceable, the main SI process took place in the Birse Parish, with new local collective leadership, a new role for civil society and a new way of organizing land ownership.

This does not mean that exogenous impulses and external actors are unnecessary for SI in rural areas. On the contrary, they can play a very important role as triggers for innovation, and are almost always present throughout these processes. However, the essence of SI, at least in our case studies, can hardly be imported or introduced from outside. This interpretation might vary if we look at SI initiatives that are conceived from the outset at a supra-local or international scale, where exogenous impulses and external actors may play a stronger role in local transformations [88,89].

6.2. The Role of Actors: Facilitators and Perceived Neutrality

A tendency exists to mainly highlight the role of innovators and promoters in SI processes [9,50,55]. Nonetheless, in the framework of our research, actors with a facilitating role are of particular interest. Their role coincides with the core SI process, namely, they are the ones who create the conditions for the reconfiguration of social relations in the territory, encouraging reflection, making the advantages of innovation visible, and designing coordination mechanisms adapted to the reality of the network of actors. The importance of these functions has also been highlighted in other studies [76]. In addition, our results also emphasize additional qualities of this role, such as normative and financial capacity, the building of networks between the territory and external organizations, and the promotion of community collective leadership.

In the case studies where clear facilitating roles were identified (CC and AMB), the facilitating actors were at the same time generators of ideas (innovators) and enabled the implementation of the activities of each initiative (promoters). Nevertheless, facilitating roles are not always clearly identified in SI processes—as is the case of BCT. Although the importance of the facilitating role is particularly relevant, it should not be forgotten; however, that they are not a sufficient condition for SI. In the preparation and implementation of innovation processes, this actor is always supported by other actors and roles, such as innovators and promoters.

The characteristics identified in the facilitator roles confer a relative attributed authority and intermediary role within and outside the rural community, in line with what Richter and Christmann [8] suggest. Notwithstanding, our study also identified another complementary characteristic that is key to SI facilitation: perceived neutrality. It is a relational and socially constructed concept that causes some actors to be perceived as politically less biased, compared with other actors. Actors perceived as neutral have greater capacity to lead SI processes. Moreover, our results suggest that the use of actors perceived as neutral contributes to the formation of networks, especially when SI processes involve radical reconfigurations and conflicts [27] or when political actors are involved. In our case studies some neutral actors followed a state logic, for example, environmental practitioners in AMB, who were perceived by environmental and business representatives as more neutral than political actors. This is also the case of SE organizations, whose nature responds to an intermediate logic. For example, IPF in AMB was perceived by local authorities and business organizations as more neutral than the other environmental organizations on Ibiza. Likewise, the new cooperative in CC, from the point of view of civil society, was perceived as more neutral than the local government, as it is historically rooted within local households. In BCT, on the other hand, a neutral actor leading the initiative would perhaps have reduced tensions between the innovator and the new members of the board team. Nevertheless, perceived neutrality is a quality of facilitating actors that may vary according to the territorial context (e.g., the trajectory and past events) and the nature of each initiative.

6.3. The Logic of Actors: Social Economy, Public Sector and LEADER

SE entities represent one of the most frequent actors playing a facilitating role. This research confirms the role of SE as a crucial actor in the activation and implementation of SI, something that has also been seen in previous research [28,50]. In all case studies we find such entities adopting innovative, promoting, and even facilitating roles. However, it is necessary to highlight that SE organizations have a particular prominence as an outcome of the SI process itself, meaning that they are ideal mechanisms to accommodate the new networks that are formed during innovation, and thus enable the implementation of collective actions [7,29,51]. AMB (association), CC (cooperative) and BCT (development trust) are all new coordination structures in the territory aligned with the premises of the SE that are created during the SI process. Mostly, aspects of process and participation turn them into coordination structures suitable for SI [48], such as the free entry of actors or their capacity to integrate the plurality of interests involved in SI initiatives. SE entities can play a crucial role as intermediaries in bottom-linked governance arrangements [8].

The role of the public sector is another controversial issue in the SI literature. The results of this research differ from the stream of studies that defend a view of SI where the public sector always has a complementary role [50,55]. Moreover, while confirming that civil society is present in all SI processes, the results raise some doubts about its necessary leading role [9,24,45]. As an example, in the initiatives located in Ibiza and Formentera, the local government—municipalities and/or island government—acted as an internal facilitator and promoter (CC and AMB), and even as an innovator (CC). Indeed, in CC, the public sector could be considered as one of the leading actors in the SI, at least in the initial stages. This confirms the results of previous studies, such as Jungsberg et al. [7]. However, in BCT, the role of local government was very weak, and it was the public sector at the national level that adopted a strategic role as an external facilitator, funding the initiative and building a legal framework conducive to local civil society-led initiatives.

Therefore, the role of the public sector depends on the scale and specific nature of each initiative [7,29] and, in particular, on the institutional context of each territory [30]. The case of BCT would be an example of a response to the weaknesses of the local governance system in Scotland, a country where local governments cover populations and territories with a much larger extension than in Spain [90,91]. Formentera would be the opposite example, where the local government's regulatory and financial capacity on the island allows it to retain a leading role in the community and, therefore, in the SI. This example illustrates that bottom-linked governance and collective leadership can also be promoted by public actors. At the same time, it confirms the contextual nature of governance and leadership processes [40]. In this sense, development trusts could come to replace the role played by local councils in rural areas of Spain, not so much at the administrative-legal level, but in terms of economic and socio-cultural promotion. Nonetheless, even in this situation, the case of BCT demonstrates that the public sector at the national level can promote SI in rural areas.

In this regard, some scholars consider that the role of the public sector might be against the necessary activation of bottom-up processes in SI in rural areas [5,92]. However, according to our results, the presence of public actors does not compromise this logic. For example, in BCT, the case where the top-down impulse was most intense, there was a clear complementarity with the leadership of local actors [93]. As a matter of fact, in all the case studies, control of decision-making was retained in the local community and was shared by a pluralistic set of actors—not only the public sector. Moreover, civil society's autonomy is strengthened through all these initiatives and through bottom-linked governance mechanisms [8].

Lastly, and in relation to the role of public policies, the strategic role of LEADER in SI processes in rural areas should be further explored. In the case studies of this research, LEADER's role was far from demonstrating the SI potential attributed to it as a facilitator and innovator [67,68]. In two of the three cases (CC and BCT) LEADER intervened through the LAGs, but its function was limited to the financing of some very specific actions, and in the other case study (AMB) its role was of little relevance. However, the role of LEADER may vary according to the nature of SI processes and other territorial factors. For example, the absence of LEADER in cases such as AMB could be explained by the very nature of the initiative, which was of a conjunctural nature and, in principle, disconnected from the rural development strategy of the area in question. In CC, the LEADER group did not fully agree on how the initiative would develop, so its role was limited to providing funding. Moreover, in Ibiza and Formentera there were several public and private actors with sufficient financial capacity and flexibility that adopted a facilitating and promoting role (as in the case of IPF and local governments). Therefore, the role of LEADER in this area focused on other activities less visible to local society (small farmers, training for NGOs, etc.). In BCT, the small area represented by the parish within the wider LEADER area, the existence of several sources of funding for local communities in Scotland, and the active role of several citizens in the parish, may be factors explaining the limited role of LEADER in the initiative.

Additionally, the progressive bureaucratization of LEADER in recent times, the loss of its role as animator, and the lack of attention from regional and national governments may also explain its limited presence in SI initiatives [72,73,94]. Nevertheless, the situation might be different in more remote rural areas or areas less connected to global socio-economic processes. In these territories, in the absence of other relevant actors, LEADER could play a more prominent role in facilitating SI [70].

7. Conclusions

Empirical research on which actors are involved in social innovation (SI) initiatives in rural territories and what role they play in these processes requires further attention from academia. This article has addressed this research gap by designing a framework based on three components: scale, role and logic. The contribution of this research derives from the empirical analysis of three case studies in rural areas of Spain and Scotland and the implementation of a comparative North–South European territorial approach. The results of the study have allowed us to better conceptualize the scale, role and logic of the actors participating in SI in rural areas. The study demonstrates that the core of social reconfigurations in SI initiatives is a local and endogenous process, which can be stimulated by external impulses. It also contributes to conceptualizing the role of facilitators in SI and identifies *perceived neutrality* as a new contextual quality that fosters network creation and collective leadership.

This research is relevant in terms of public policy because it describes the effective role that both local and national governments can play in SI in rural areas. It presents situations in which local authorities drive SI processes as innovators, promoters and/or facilitators. The potential role of national governments legitimizing creative local actions is also illustrated. From this study we derive the need to support social economy entities as an arena for SI and rural development. Finally, a more active role of LAGs–LEADER as promoters, innovators and facilitators seems to be required, especially in the most disadvantaged areas. However, this issue should be further explored in future research projects. The next research steps also need to focus on the role of actors in SI in a greater diversity of territories, comparing less affluent and more affluent rural areas.

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Data Availability Statement: The data presented in this study are available on request from the corresponding author. The data are not publicly available due to interviewees' privacy and ethical restrictions.

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Appendix A

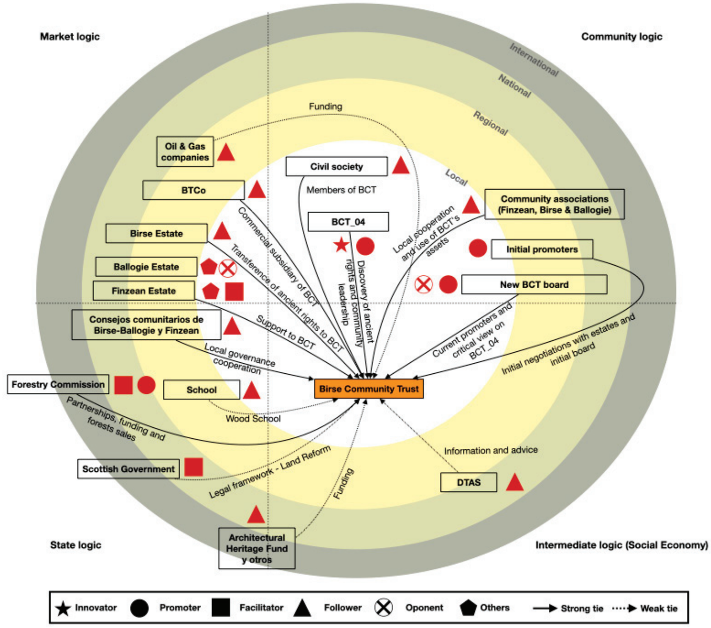

Figure A1. Actors involved in Birse Community Trust. Own elaboration.

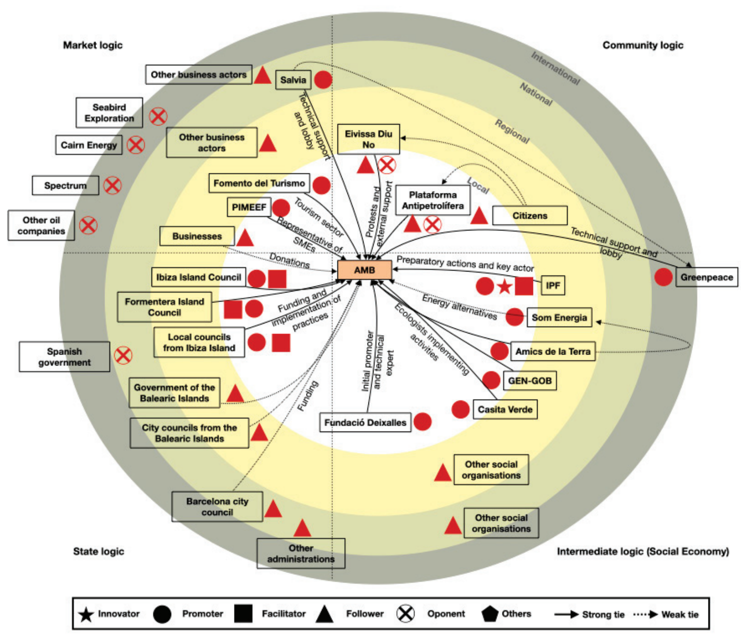

Figure A2. Actors involved in Alianza Mar Blava. Own elaboration.

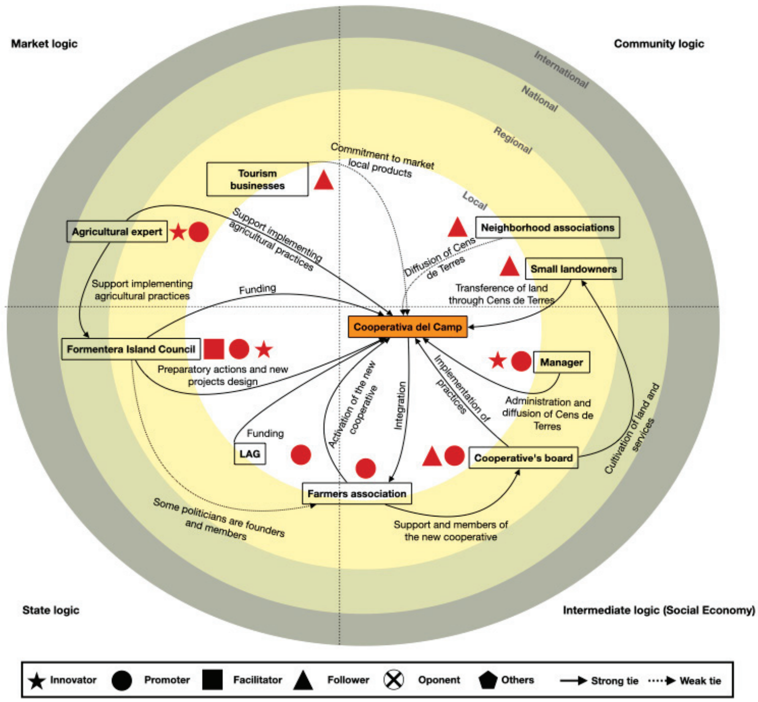

Figure A3. Actors involved in Cooperativa del Camp. Own elaboration.

Notes

1 The LEADER program (Liaisons entre Actions de Développement de L'Economie Rural) was launched in 1991 as part of the EU's rural development policy as an area-based, integrated and bottom-up method for delivering rural development.

2 https://www.marblava.org. (accessed on 5 April 2022)

3 https://www.birsecommunitytrust.org.uk.(accessed on 23 January 2022)

4 From April 2019 the Forestry Commission has been split into two entities: Forestry and Land Scotland, as the body responsible for the management and promotion of publicly owned forests and land; and Scottish Forestry, responsible for forestry policy in Scotland and regulatory matters beyond public land.

5 Although LEADER Local Action Groups are not strictly public bodies, we mention them in this section as they are closely connected (and socially perceived) with the offices of local authorities in the UK context.

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Article

Nature-Based Solutions Benefit the Economic–Ecological Coordination of Pastoral Areas: An Outstanding Herdsman's Experience in Xilin Gol, China

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Abstract: Grassland has always had a difficult economic–ecological relationship, as coordination between its ecological conservation and the sustainable development of animal husbandry is required. Nature-based Solutions (NbS), who make full use of the natural ecosystem services, have successfully solved some economic–ecological issues, but still have unclear implementation prospects for grassland management. The Xilin Gol grassland is one of the most typical pastoral areas in China; there is a village chief named Bateer, who has already used NbS for grassland management. To confirm whether the solutions employed by Bateer have been effective for both increasing economic profits and protecting grassland ecosystem, we interviewed him, and many other herdsmen, using questionnaires about their livelihood. Based on these questionnaires, we calculated and compared their income–cost ratios. Meanwhile, we analyzed the NDVI variations inside their rangelands through high-resolution remote sensing images. The results showed that the herdsmen in Bateer's village had a much higher disposable income and income–cost ratio than others, and their rangelands also had a higher value and a more obvious increasing trend of NDVI. Bateer's success proves that the NbS can also play a positive role in grassland management, which can provide a valuable guidance for economic–ecological coordination in pastoral areas.

Keywords: Nature-based Solutions (NbS); economic–ecological coordination; grassland management; ecological conservation; animal husbandry

1. Introduction

Animal husbandry is an important part of primary industry, and also the main food source of human society, especially beef and milk, which provide protein, fat and other necessary nutrients to our daily lives [1]. Although the proportions of the secondary and tertiary industries are increasing because of industrialization and urbanization, animal husbandry still owns an important status, especially for those herdsmen for whom animal husbandry is still the only income source available to maintain their normal livelihood. Grassland, occupying about 40% of the global land surface area, is the material basis of animal husbandry, which determines the production intensity and economic benefit of animal husbandry [2]. The global grassland, however, is now under intensive ecological pressure; around 49% of grasslands have suffered ecological degradation, which has thus caused a series of ecological and social problems [3,4]. As an important terrestrial ecosystem and biodiversity depository, ecological degradation of grassland will weaken the stability and balance inside the ecosystem, and pose a threat to the survival of many species [5–8].

Grassland can also play an important role in mitigating greenhouse gases to support global carbon storage and sequestration, which will be undermined by ecological degradation [9]. Moreover, ecological degradation also reduces the productivity of grassland, which cannot provide strong support for animal husbandry production, thus causing the poverty of herdsmen, and economic stagnation [9–13]. Therefore, preventing ecological degradation and realizing the sustainable development of animal husbandry is always the biggest theme of grassland management, which requires economic–ecological coordination.

Effective management is key to realizing economic–ecological coordination on the grassland, and many countries have proposed a series of different policies and measures to promote the development of animal husbandry, and protect grassland ecosystems. For example, some developed countries have planted a large area of artificial grassland with higher primary productivity and forage yield to replace natural grassland, and have also adopted some high-technology measures, such as automatic feeding and nutritional monitoring systems [14–19]. In addition, European countries such as Switzerland have provided very high financial subsidies for herdsmen to encourage them to keep livestock number within the grassland carrying capacity, and given rewards or punishments according to their performances [20–24]. Other countries, such as the Netherlands and New Zealand, have established a herdsman–enterprise production cooperative, and carried out exclusive training on herdsmen regarding new technologies of grassland management [25–32]. The popularity of artificial grassland and effective supporting measures have brought about the economic–ecological coordination of grassland in such countries.

China has both the largest grassland area and herdsman population in the world; thus, the ecological conservation of grassland and sustainable development of animal husbandry are extremely important in China. To realize economic–ecological coordination, the Chinese government has also proposed a series of policies and measures in pastoral areas, including grassland–livestock balance, house feeding, and banning and delaying grazing to adjust the previous production style, mainly through targeted intervention. So far, however, the economic and ecological effectiveness of such measures have not been obvious, and have faced some controversies [33–37]. For example, as a typical measure of grassland management in China, fencing has always been the main focus of relevant studies, and has aroused many debates. Some believe that fencing can bring a significant improvement of ecological condition and husbandry productivity [38–43], whereas others argue that long-term fencing causes poisonous weeds to expand and encroach on the living spaces of other grass species, thus resulting in biodiversity loss and re-desertification [44,45]. Some studies, however, have recently begun to move away from the dispute between traditional and fenced grazing, and explore new ways for grassland management to coordinate economic growth and ecological conservation [46]. Therefore, due to the huge demand for herdsmen's income increase and grassland ecological conservation in the pastoral areas in China, obtaining good economic benefits without destroying grassland ecosystems deserves further exploration.

Nature-based Solutions (NbS), firstly put forward by the World Bank in 2008, and officially defined by the International Union for Conservation of Nature (IUCN) in 2009, have recently become more and more popular due to the shortcomings of human intervention. The NbS advocate to make full use of natural ecosystem services to create natural, social and economic benefits at the same time, and build a human–nature community. The cost is much lower than human intervention, and it has already been successfully put into practice for the issues of climate change and urban ecosystems [47–52]. In 2020, IUCN launched the global standard of NbS, including eight criteria and 28 indicators, with the aim to summarize the achievements of NbS and avoid some misunderstandings [53]. As for the pastoral areas, however, few studies have so far focused on the NbS to solve the contradiction between grassland ecological protection and husbandry production [54,55]. Fortunately, we became acquainted with an outstanding herdsman named Bateer during our investigation in Xilin Gol in 2019, who emphasized the importance of maximizing the natural power of the grassland ecosystem instead of human high-intensity intervention.

Taking several new measures of rangeland management and has gathered excellent economic and ecological benefits. He is now well-known in the neighborhood, and greatly influences other herdsmen who have visited him to learn from his experience. We conducted an exclusive interview with Bateer, and found that his unique ideas are a valuable reference for economic–ecological coordination in pastoral areas, and are worthy of further study and discussion.

Therefore, based on the herdsman questionnaires in our investigation, and high-resolution remote sensing data, we summarized Bateer's measures and analyzed his and other herdsmen's livelihoods and ecological change characteristics inside the rangelands, to assess the economic and ecological effectiveness of Bateer's measures, compared with other herdsmen's. Thus, we can provide a reference for the NbS for the future implementation of economic–ecological coordination in the pastoral areas of China.

2. Materials and Methods

2.1. Study Area

The Xilin Gol League is located in the middle of Inner Mongolia, along the northern border of China. Three main grassland types are all distributed there because of the spatial variations and the moisture conditions. The meadow grassland is in East and West Ujimqin, in the northeast, and the desert grassland is in Erenhot, Sonid Left and Sonid Right, in the west, while the central region with a large area is mainly covered by typical grassland (Figure 1). Furthermore, the vast majority of Xilin Gol is located in the north of China's agro-pastoral ecotone, and has always been the most active region for nomads and traditional large-scale grazing (Figure 1). In the southern area of Zhenglan and Abaga, near the agro-pastoral ecotone, however, the husbandry production has shown more characteristics of human intervention under the influence of agricultural civilization. Therefore, Xilin Gol has the most diverse ecological grassland background conditions and, corresponding to husbandry production measures, this makes it an excellent place for relevant studies.

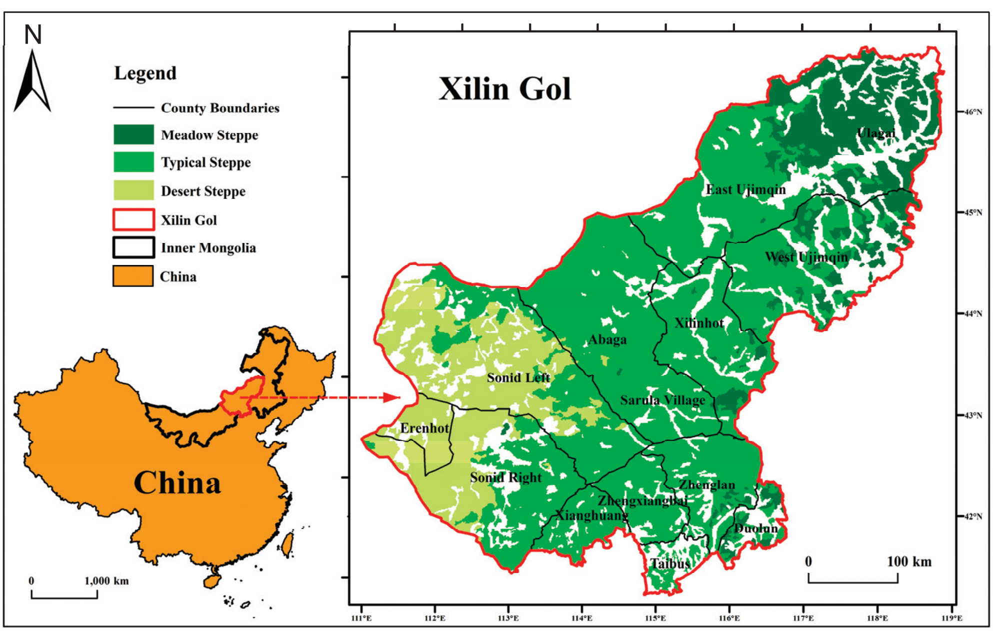

Figure 1. The grassland in Xilin Gol.

Bateer is an outstanding herdsman, who had his own ideas for grassland ecological conservation and husbandry production. In 1993, he became the chief of the Sarula village in Abaga, where serious grassland degradation and poverty existed at that time because of the constant drought and overgrazing. Facing this dilemma, he made efforts to restore the grassland and increase the herdsmen's income through a series of creative and effective measures. Under his leadership, the poverty in his village has been completely reversed, and the local grassland ecological condition has also been greatly improved. As a result of his legendary experience and huge contribution to local development, he was just awarded a "July 1st Medal", the highest honor of the Communist Party of China.

2.2. *Data Collection*

2.2.1. Questionnaires

We interviewed 130 herdsmen in different counties through questionnaires, mainly including the costs of husbandry production and their incomes (Figure 2). In each herdsman's family, we took photos of typical landscapes and production facilities. We kept a detailed record of each questionnaire to summarize the herdsmen's livelihood and current measures they take. As for Bateer, we conducted a long-time interview with him, and carried out a field observation in his rangeland, as well as some other herdsmen in the Sarula village.

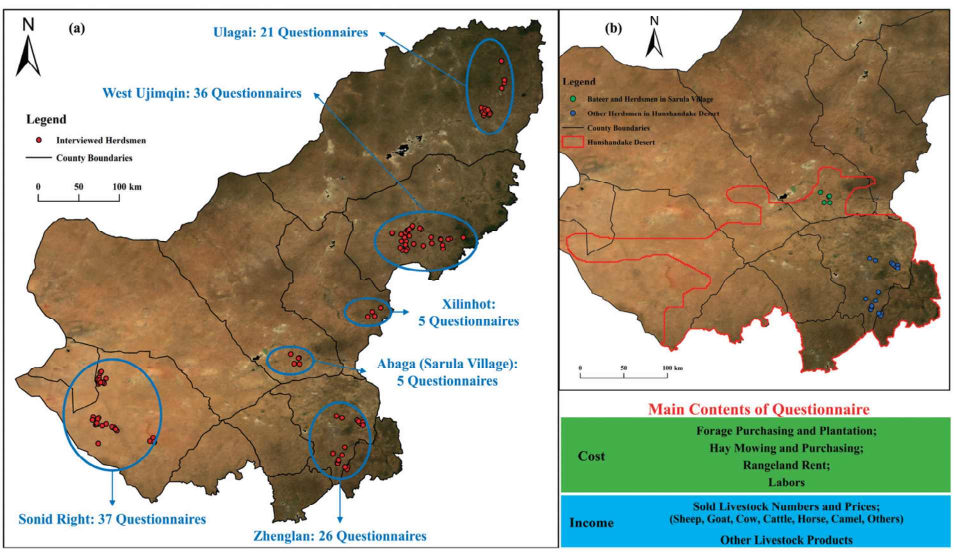

Figure 2. The locations of interviewed herdsmen in (**a**) Xilin Gol and (**b**) Hunshandake desert.

2.2.2. Statistical Yearbook

To supplement the questionnaire data, we also referred to the Xilin Gol Statistical Yearbook and the Bulletin on husbandry Development, which were launched by the Bureau of Statistics and the Agriculture and Husbandry Bureau of Xilin Gol, to achieve data on livestock numbers, economic growth and the herdsmen's income [56,57].

2.2.3. Remote Sensing

The Normalized Difference Vegetation Index (NDVI) is the best indicator of the vegetation coverage, which can effectively reflect the health and stability of the grassland ecosystem [58–60]. In this study, we chose the Sentinel-2 satellite data with a spatial resolution of 10 m, in order to show more detailed information of the land surface and acquire a more accurate result. We selected the images of Xilin Gol in 1993, 1998, 2003, 2008, 2013 and 2018, to analyze the rangeland ecological changes after Bateer became the chief, and his measures were popularized in Sarula village. For each year, the images from May to August (the time when the grassland has its best ecological condition in the year) were synthesized to calculate the NDVI as the annual vegetation coverage level.

2.3. Methodology

2.3.1. Assessment of Economic Effectiveness of Bateer's Measures

We evaluated the economic effectiveness based on the "income–cost ratio" in the husbandry production, specifically comparing the annual costs and incomes (financial subsidies not included) of the interviewed herdsmen in different counties. According to our questionnaires, the cost and income of a herdsman family can be calculated as:

$$C = C_{forage} + C_{hay} + C_{rent} + C_{labor} \tag{1}$$

$$I = \sum_{i=1}^{n} (L_i \times P_i) + I_{others} \tag{2}$$

Specifically, C is the total cost of a herdsman family; C_{forage}, C_{hay}, C_{rent} and C_{labor} represent the cost of forage purchasing and plantation, hay mowing and purchasing, and rangeland rent and labors, respectively. I is the total income of a herdsman family; i represents the livestock type (sheep, goat, cow, cattle, horse, camel, others) and n represents the number of livestock types; L_i and P_i represent the number and price of the sold livestock type; I_{others} represents the income from other livestock products.

Then, the "income–cost ratio" was calculated in each herdsman family:

$$R = {}^{I}/_{C} \tag{3}$$

The higher the value, the better economic effectiveness the family had. Therefore, we could judge the economic effectiveness of Bateer's measures by comparing the ratio of the herdsman groups in Sarula village and other regions.

2.3.2. Assessment of Ecological Effectiveness of Bateer's Measures

Sarula village is located in the Hunshandake desert, one of the most important ecological conservation areas in the south of Xilin Gol, and the grassland ecological condition within Hunshandake desert is nearly the same. The interviewed herdsmen in Zhenglan were all within this range. Therefore, we compared the NDVI in the rangelands of herdsmen in Sarula village, and others also within the range of the Hunshandake desert, in order to eliminate the uncertainty caused by different geographical background when assessing the ecological effectiveness of Bateer's measures. According to the questionnaire results, we created a 1-km buffer of each herdsman's location as the rangeland, and used it as a mask to extract the NDVI data in ArcGIS. We compared the NDVI of the two groups in 2018, together with the temporal variation slopes from 1993 to 2018, to judge if Bateer's measures had brought a better ecological condition or a significant trend in the rangeland. The slope was calculated with Raster Calculator in ArcGIS, using the following formula:

$$slope = \frac{n\sum\limits_{i=1}^{n}(i \times NDVI_i) - \sum\limits_{i=1}^{n} i \sum\limits_{i=1}^{n} NDVI_i}{n\sum\limits_{i=1}^{n} i^2 - (\sum\limits_{i=1}^{n} i)^2} \tag{4}$$

Specifically, i represents the year (1993, 1998, 2003, 2008, 2013, 2018) and $n = 6$; $NDVI_i$ represents the NDVI value of the rangeland in such year.

3. Results and Analysis

3.1. Bateer's Measures and Comparison with Others

The grassland–livestock balance is the core of all policies for rangeland management in the pastoral areas of China [61–63] based on which most local herdsmen in Xilin Gol take a series of measures, including banning and delaying grazing, house feeding, and forage plantation, with the aim to adjust the traditional husbandry production pattern. These measures do have some effectiveness in grassland ecological conservation, but they all rely on human intervention, which requires large amounts of labor and financial support. Thus, this reduces the economic benefits of husbandry and increases the burden on herdsmen's lives. Therefore, there is still some uncertainty in coordinating economic growth and ecological conservation.

With the help of the local government, we conducted an exclusive interview with Bateer and summarized his experience. "Hoof Theory" describes the habits and economic benefits of cattle and sheep on grassland, and is the result of Bateer's observations. Specifically, the profit of cattle is five times that of sheep, but they have the same number of hooves treading the grassland. Moreover, the cattle feed with their tongues rolling, while the sheep with their hooves digging. Therefore, the sheep bring more pressure onto grassland ecosystem than the cattle, and offer lower economic benefits. Under the guidance of "Hoof Theory", the number of sheep and goats in Sarula village has been largely reduced, and replaced with high-quality cattle breeds which are less susceptible to disease, and grow faster. Now, the cattle occupy 98% of the total livestock; therefore, the livestock structure in Sarula village is different from the overall livestock structure in Xilin Gol, in which sheep and goats have the largest proportion (Figure 3a). Meanwhile, the questionnaires showed that the average livestock number in Sarula village was about 50, only one third of the interviewed herdsmen's stock in other counties (Figure 3b).

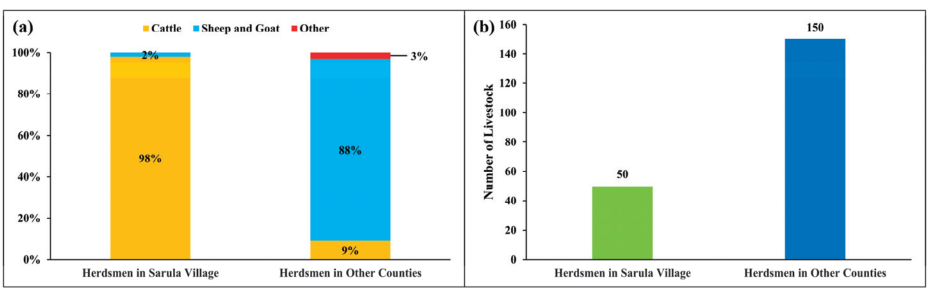

Figure 3. (**a**) livestock structure and (**b**) livestock number of Sarula village and other counties.

In addition, Bateer also takes some creative measures:

(1) Paddock grazing. Bateer choses to graze on the premise of grassland–livestock balance, and has adopted paddock grazing through the establishment of fences, to avoid the overuse of any rangeland and make sure that there is enough time for grassland recovery;

(2) Cold-resistance training for livestock. Bateer does not take any special care of livestock in winter, and only gives some aid when severe cold disaster happens, with the aim to promote their ability to survive in the harsh environment;

(3) Hay mowing without home storage. Bateer has adopted a new method to mow the grass where he directly scatters the mowed grass on the rangeland, for livestock to eat, instead of transporting it home for storage.

Bateer provided new ideas for both grassland ecological conservation and husbandry production, which contain his empirical knowledge obtained through long-term observation and practice on the grassland. Bateer's success is because the measures are all based on the theories of ecology and biology, rather than subjective judgements. Moreover, these measures are all in line with local herdsmen's lifestyle and husbandry development needs, so there are no obstacles in their implementation (Table 1).

Table 1. The bases and advantages of Bateer's measures.

Bateer's Measures	Bases and Advantages	Corresponding Other Measures
Paddock grazing	There is not too much pressure on any rangeland for a long time, and the resilience of the grassland ecosystem means that it recovers soon after grazing [64–68]. Grazing is not interrupted to ensure the sustainable output of husbandry.	Banning and delaying grazing
Cold-resistance training for livestock	Those cold-resistant livestock will survive without aids in the winter according to the "survival of the fittest", and this cold-resistant ability will be inherited by the offspring and passed on from generation to generation.	Greenhouse and medical aids
Hay mowing without home storage	The livestock can feed easily without additional disturbance to the grassland such as trampling and digging behaviors.Transportation and storage costs are saved.	House feeding and forage plantation

3.2. Assessment of the Effectiveness of Bateer's Measures

3.2.1. Economic Effectiveness

The income–cost ratio of herdsmen in Sarula village was 3.64, whereas such values in other counties were much lower, meaning that herdsmen in Sarula village could acquire twice or more economic profit than herdsmen in other counties, with nearly the same financial and labor costs under the guidance of Bateer's ideas (Figure 4a). Therefore, the adjustment of livestock structure, and the decrease in livestock number, did not result in economic loss but brought a huge increase in economic benefits. The per capita disposable income of Sarula village had increased from 700 RMB in 1993 to 40000 RMB in 2018, more than three times that of other herdsmen in Xilin Gol, which was undoubtedly an economic miracle [56] (Figure 4b).

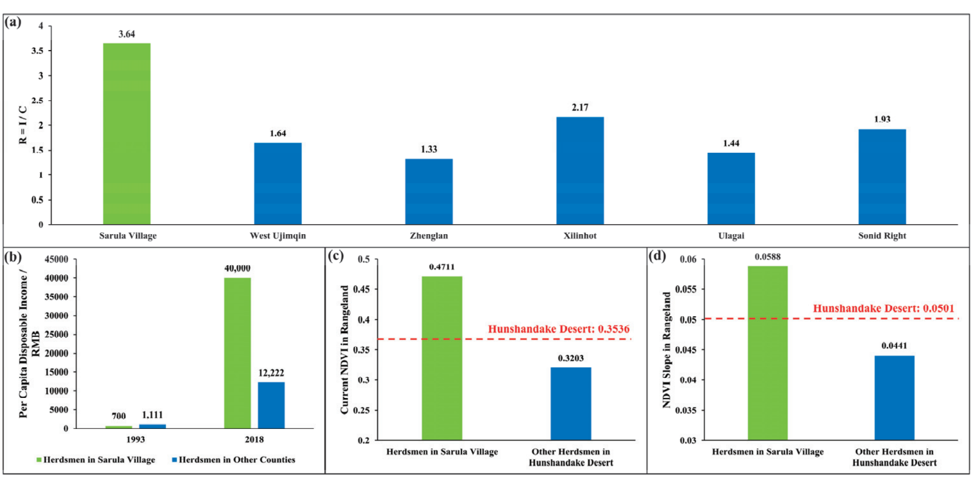

Figure 4. (**a**) Income–cost ratio; (**b**) Per capita disposable income; (**c**) current NDVI; and (**d**) NDVI slope inside rangelands of herdsmen in Sarula village and other counties.

3.2.2. Ecological Effectiveness

The current NDVI of rangelands of herdsmen in Sarula village is 0.4711, higher than the overall level in the Hunshandake desert, while that of other herdsmen in the Hunshandake desert is only 0.3203, reflecting that the overall vegetation coverage inside the rangelands was much better in Sarula village than others (Figures 4c and 5a). As for the NDVI slope, the NDVI inside rangelands of herdsmen in Sarula village showed a significant increasing trend (slope = 0.0588), and a better ecological recovery trend than other herdsmen, and the whole Hunshandake desert (Figures 4d and 5b). The results showed that, through paddock grazing and hay mowing without transportation, Bateer has not only effectively maintained the stability of the grassland ecosystem, but also improved it to a condition superior to other grassland of a similar geographical background. This proves that his measures offer huge advantages in ecological conservation.

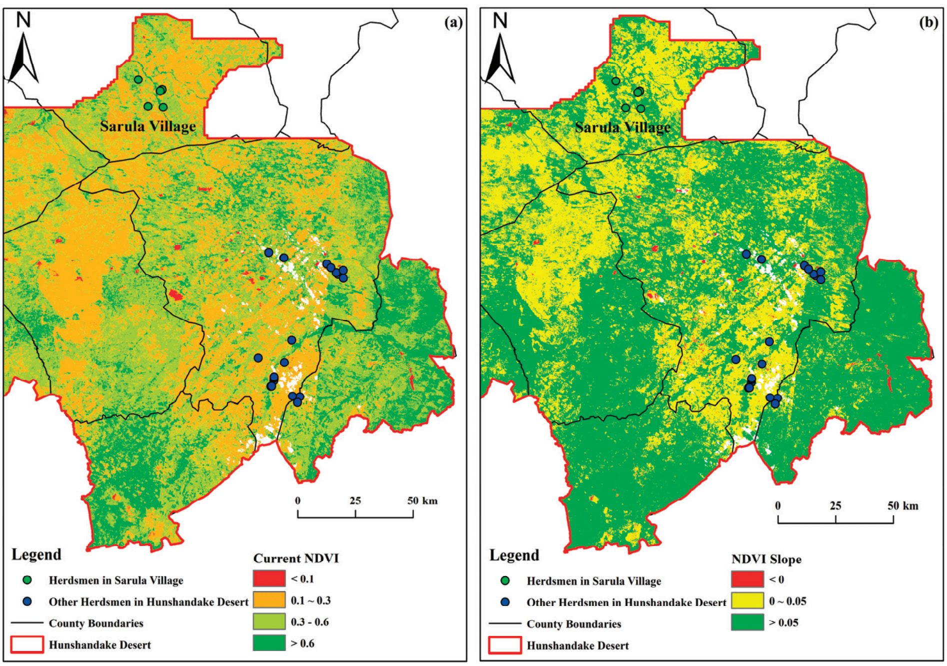

Figure 5. The spatial variations of (**a**) current NDVI, and (**b**) NDVI slope inside the rangelands of herdsmen in Sarula village and others in the Hunshandake desert.

4. Discussion

4.1. Adopt the NbS for Future Economic–Ecological Coordination in Pastoral Areas

Bateer's measures and the current measures represent the NbS, and human intervention, respectively. The implementation of NbS has obvious advantages to achieve economic–ecological coordination on the grassland. Firstly, the difference between them results from the basic ideology of grassland management (Figure 6). The current measures emphasize human intervention, such as banning and delaying grazing to avoid the overuse of grassland, and limitations on grazing, whereas house feeding, silage corn plantation and livestock breeding improvement reduce the pressure on grassland and maintain husbandry production through targeted adjustments of grazing. Bateer firmly believes that the ideal situation is the harmonious coexistence of all species, including human beings, rather than herdsmen acting as the leader of grassland ecosystem. Therefore, he advocates reducing human intervention and mainly relying on the ecosystem services of grassland itself for ecological restoration and husbandry production, which can obtain the economic benefits of husbandry with minimum costs. Although human intervention can also curb the grassland degradation and ensure the continuity of husbandry production, it costs much more than NbS, and once human intervention has been interrupted, it will be difficult to maintain a good ecological condition and animal husbandry productivity.

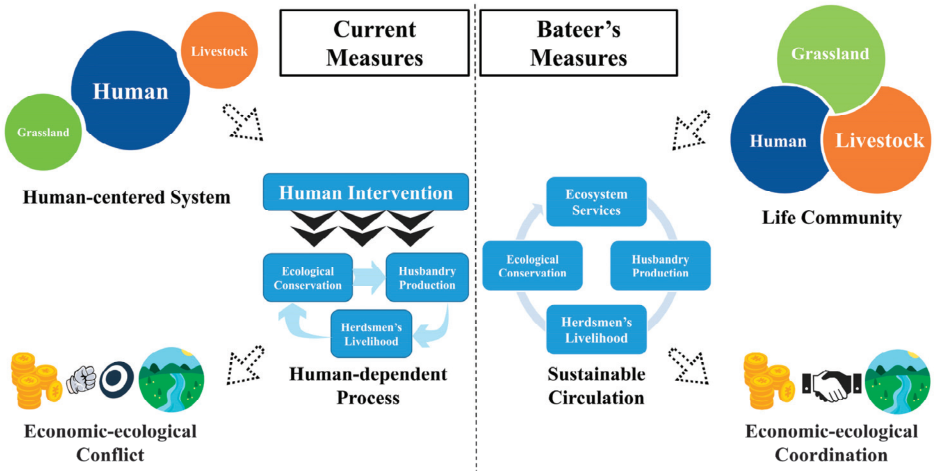

Figure 6. Comparison between human high-intensity intervention (current measures) and the NbS (Bateer's measures).

Secondly, given the traditional animal husbandry production pattern and herdsmen lifestyle, the NbS may be the most suitable way to realize the economic–ecological coordination on the grassland in China. Specifically, the main pastoral areas in China are all distributed in the northern part, where the nomadic culture has been constantly inherited for thousands of years, especially Xilin Gol. Therefore, most local herdsmen still prefer to insist on grazing rather than extra intervention such as house feeding and artificial grassland, which was proven in our field investigation in Xilin Gol. In comparison, the popularity of artificial grassland and the application of high-technology intervention measures face fewer obstacles in developed countries, such as America, New Zealand and European countries, because there are more advanced economic and technological levels and mature market mechanisms [25–32]. We do not mean that such measures taken by developed countries are not suitable for China; however, presently, the NbS could be the best choice according to current conditions in the pastoral areas of China, as they are much easier to be approved and accepted by local herdsmen.

To apply NbS more effectively in the grassland pastoral areas, NbS should include two important aspects. Firstly, the grassland ecosystem should be restored mainly based on its own resilience, with the support of suitable policies and measures. Secondly, a life-community of grassland, livestock and human beings should be built, in which human beings are not superior to other species. Moreover, a regional social–ecological system is most resilient when policies and measures are fit for the geographical and social background; the proper human intervention which supports the smooth implementation of NbS could offer suitable policies and measures for different regions. So, in the future, we should consider the local geographical and social background first, to make sure that NbS will achieve the desired effect on animal husbandry production and grassland ecological conservation. Furthermore, NbS ultimately have better feasibility and effectiveness because of a high local suitability; therefore, any solution that has had proven success in one region cannot be directly copied into another. Meanwhile, NbS may need timely adjustments in the future to keep pace with the latest conditions of grassland and animal husbandry. Additionally, we must be aware that, NbS does not mean the abandon of human intervention and the adoption of only natural ecosystem services. The essence of NbS is that the natural ecosystem services play an effective and sustainable role with the help of proper human intervention, which means taking human intervention as a complement to nature, rather than the opposite.

4.2. Take Advantage of Fences to Support NbS Implementation

Fences are indispensable and have effectively guaranteed the smooth implementation of Bateer's measures, especially paddock grazing. For the effective application of NbS on the grassland, fences will play an important and imperative role; they are widespread in the grasslands of many countries and have performed well in ecological conservation and animal husbandry production in many pastoral areas. The establishment of fences has meant successful pasture allocation among herdsmen, and avoided the severe ecological degradation caused by "the Tragedy of the Commons" [69–71]. As for husbandry production, fencing reduces the range of livestock activities and avoids the external interference from wild animals on livestock, so as to greatly improve the efficiency of husbandry production [72–74]. As for ecological conservation, fencing and paddock grazing set aside enough time for grassland self-recovery, significantly improving the stability and productivity of the grassland ecosystem inside the enclosures [38–43]. Bateer has also made full use of fences to support his measures and achieve success.

However, there are also some debates about the negative influence of fences, which we must be aware of and properly deal with, in order to minimize this negative effect and guarantee the effectiveness of NbS. For example, some studies have shown that long-term (older than 8 years) fencing has not brought any ecological and economic benefits, and has even caused some new ecological problems [45]. Specifically, long-term fencing will lead to the rapid growth of weeds, which seriously encroaches on the living space of other species, destroys the original structure of the grassland ecosystem, and reduces biodiversity. Therefore, it is necessary to remove the weeds to avoid hindering the growth of other forage grasses. Long-term fencing also leads to wildlife habitat fragmentation and migration isolation, so the establishment of fences must leave migration corridors for wild animals.

Therefore, the main reason for the negative impact of fencing is the lack of management, not fencing itself. In order to provide powerful support, we recommend that the NbS, as a long-existing grassland management measure, should consider how to use fences properly to achieve the best effectiveness, rather than falling into the dispute between "should use" and "should not use", or traditional and fenced grazing. Necessary management needed to fully utilize the advantages of fences and avoid their adverse effects as far as possible. In addition, the use and purpose of fencing should be fully considered. For example, to separate protected areas or other special areas from pastures, a permanent fixed fence should be used for strict limitation. To separate herdsmen's rangelands, a mobile electric fence should be used for more flexible management, in case of wildlife or livestock migration. Moreover, based on the satellite, UAV and field survey, we can also monitor the temperature, precipitation and grass growth inside the fences, and thus grasp the latest grassland dynamics, and adjust the fences in time.

In summary, the establishment of fences symbolizes the adjustment and optimization of traditional grazing, combining science and technology with nature. Fences will definitely become a very useful tool of NbS for future grassland ecological conservation and the sustainable development of animal husbandry. Therefore, we must move away from the "traditional or fenced grazing" dispute, and properly make use of fences to make the advantages outweigh the disadvantages, and thus support the NbS for grassland management in pastoral areas.

5. Conclusions

The contradiction between economic growth and grassland ecological conservation needs proper resolution in order to achieve high-quality and sustainable development in pastoral areas. Based on the results of the investigation in Xilin Gol, we summarized the experience of Bateer, an outstanding herdsman who has successfully applied NbS in rangeland management, making full use of the natural ecosystem services to replace unnecessary human intervention, and reducing the labor and financial costs of grassland management. The results showed that, compared with other interviewed herdsmen, such measures taken by Bateer not only protected the grassland ecosystem, but also significantly improved the herdsmen's income and the economic benefits of animal husbandry. That is to say, NbS (Bateer's measures) are more effective than human high-intensity intervention (current measures) for realizing economic–ecological coordination in pastoral areas. For NbS implementation and economic–ecological coordination in pastoral areas, Bateer's success provides valuable guidance, which can be summarized by the following three points:

1. Maximize the grassland ecosystem services on the basis of ecological conservation;
2. Adopt a "lower number but higher quality" livestock structure to solve the economic–ecological contradiction;
3. Promote the livestock's adaptation to natural disasters, in order to enhance survival ability and reduce the death rate of the livestock.

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Spatial Distribution and Driving Forces of the Vegetable Industry in China

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Abstract: Based on the ArcGIS geostatistical analysis method, this study offers a visualization of the spatial distribution pattern and spatial trend of vegetable production in China. The research also examines the degree of spatial agglomeration patterns of vegetable production by using the standard deviation ellipse technique and exploratory spatial data analysis method. In addition, we employ the spatial regression model partial differential method to explore the driving factors leading to the changing layout of vegetable production. The findings unveil that vegetable production in China exhibit strong spatial non-equilibrium characteristics, with "high-high" and "low-low" types as the main agglomeration patterns. Furthermore, the location distribution shows a northeast–southwest orientation with the center of gravity of distribution gradually directed toward the southwest. Regarding driving factors, the results show that the effective irrigated area of natural factors had a facilitating effect on the layout of vegetable production, while the affected area had an inhibiting effect on it. Climate indicators such as temperature, precipitation and light show different degrees of influence on the layout of vegetable production. The level of urbanization and transportation conditions have a negative impact on the layout of production in the region. Market demand has a positive spillover effect on the layout of local vegetable production, while it has a negative spillover effect on other regions. Technological progress shows positive spillover effects on the layout of vegetable production in the region and other regions. Financial support policy also shows positive effects from an overall perspective.

Keywords: spatial distribution; spatial agglomeration; standard deviation ellipse; spatial regression model partial differential method

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1. Introduction

The vegetable sector is a pillar sector of any national economy, playing a vital role in increasing farmers' incomes and promoting employment, as well as transforming agriculture. In the context of China, it also plays an irreplaceable role in optimizing planting structure and boosting rural economic development. The vegetable-sown area in China in 2019 reached 20,862,700 hectares, and production spiked up to 721 million tons, with a per capita possession of about 515.86 kg. China is both acknowledged as a large producer and consumer of vegetables. According to the Food and Agricultural Organization of the United Nations (FAO, 2019), China's vegetable-sown area and production accounted for 52.25% and 58.31% of the world's total planted area and production, and it ranked first in the world.

At present, the development of China's vegetable industry has achieved remarkable results. However, there are still problems such as unbalanced spatial development and low degree of organization, especially the unbalanced spatial development of the vegetable industry, which has seriously hindered the development and growth of a high-quality agricultural economy. The spatial distribution of vegetable production has dramatically changed in China due to increasing marketization in agriculture, population growth, and rapid urbanization [1–4]. Moreover, the vegetable sector faces many other challenges, such as rapidly rising production costs, price volatility, and consumers' increasing concern for product quality and safety. These issues arise from structural, seasonal and regional imbalances between vegetable supply and demand, and they are closely related to spatial distribution, as well as to the organization and management of vegetable production, such as the increasing issues of excess capacity in the vegetable sector [5–7].

Along with the strong promotion of agrarian supply-side structural reform, the agricultural production structure urgently needs adjustment. The report of the Central Government (2021) pointed out the need to build a modern rural industrial system, modern agricultural industrial parks, strong agricultural industry towns, and advantageous special industrial clusters. The Fourteenth Five-Year Plan for National Economic and Social Development of the People's Republic of China and the Outline of the Vision 2035 (the Fourteenth Five-Year Plan) also emphasizes the modification of agricultural structure, optimizing the layout of agricultural production, building advantageous agricultural product industry belts, and promoting strategic areas with special agricultural products to boost rural revitalization. Against this backdrop, it is of great particular significance to examine the spatial agglomeration characteristics of China's vegetable industry and its evolutionary trends and explore the driving factors of its layout changes to promote the rural revitalization broadly and to accelerate the development of agricultural and rural modernization.

Agricultural Location Theory was first introduced by German agricultural economist von Thunen in 1826 [8]. It was proposed that the pattern of agricultural production is a concentric circle structure with a circle distribution centered on cities. Farmers' production decisions are influenced to a large extent by geographical location. Vegetables are located in the first circle, i.e., the free farming circle. Along with the gradual advancement of the market economy and the booming infrastructure and transportation industry, this theory has encountered significant practical challenges [9]. In the 1990s, Krugman, a representative of the new economic geography theory, refined this theory by adding spatial analysis. Given the assumption of increasing returns and imperfect competition, Krugman analyzed the mechanism of spatial agglomeration from the perspectives of economies of scale, transportation costs and market demand [10]. The relationship between industrial agglomeration and regional economic growth was explored. The study proposed that industrial agglomeration formation is a trade-off between increasing returns to scale and transportation costs, inferring that industrial agglomeration provides economic benefits to the residents. In contrast, those residents who belong to non-agglomeration areas are not likely to avail such benefits due to increased distance issues. The new economic sociology represented by Granovetter considers institutions, culture, knowledge, and geographical location as crucial factors of spatial agglomeration [11].

In the context of agricultural production, various scholars and researchers have directed their attention to the spatial distribution phenomenon to reveal the agricultural production layout in the context of food crops, cash crops, and animal husbandry. A large amount of literature has emerged on studying spatial layout variation of food crops [12–15]. In the context of cash crops, the main emphasis is given to analyzing the production layout changes in the apple [16,17] and cotton commodities [18]. In the context of the spatial layout of the vegetable industry, Bao et al. [19] revealed that comparative advantage, non-farm employment opportunities, transportation conditions, and urbanization level are the main reasons affecting the layout of the vegetable industry. Technological progress has less influence on the layout of the vegetable industry. In addition, in the spatial layout of the livestock industry [20], many studies explored the spatial layout of the dairy industry [21,22] and the layout of pig production [23,24].

In the existing literature, a handful of studies analyzed the spatial pattern and dynamic changes in vegetable production in China; however, these studies have several limitations. First, most of the studies in the prevailing literature used location entropy or production concentration index to measure the degree of agglomeration in the vegetable industry. These studies failed to provide a clear picture of agglomeration characteristics from a spatial perspective. Second, the study of vegetable production layout involved different regions' natural resource endowment characteristics and failed to consider spatial factors. Still, the studies that used spatial econometric models to explore the driving factors of the change in vegetable production layout are relatively rare. Based on these backdrops, the marginal academic contribution of this paper is to discuss in depth the distribution pattern and evolution trend of vegetable production in China. The study further attempts to explore the degree of spatial agglomeration and the spatial agglomeration pattern of vegetable production in China using the standard deviation ellipse technique and exploratory spatial data analysis methods. The study constructed an analytical framework for assessing the influence mechanism and employed the partial differential method of spatial regression model to examine the influencing factors of the changing layout of vegetable production in China based on the spatial perspective. The outcome of this study provides empirical evidence to boost the decision-making concerning optimizing the layout of vegetable production in China.

Thus, the rest of this study is structured as follows: Section 2 theoretically discusses the influencing factors of vegetable production layout. Section 3 introduces the data and primary methods used in the analysis. Section 4 provides a descriptive analysis of the spatial distribution and spatial agglomeration of the vegetable industry in China. In addition, we also use a spatial econometric model to empirically analyze the factors affecting the vegetable production layout. Section 5 concludes with a summary of the major findings and policy implications.

2. Theoretical Framework

A mature and complete theoretical analysis framework has not been developed for the spatial aggregation of vegetable production. The change in vegetable production layout in China is the result of the combined effect of natural, economic, transportation, market, technology, and policy factors. Among them, natural factors are the most direct factors that cause the change in vegetable production layout, while economic, transportation, market, and technology factors have indirect effects on the shift in production layout by affecting the cost and income of vegetable cultivation. The above factors influence the vegetable planting decision of farmers, which in turn affects the change of vegetable planting area and yield, leading to a shift in vegetable production layout. This study analyzes the influence mechanism of changing vegetable production layout in China based on agricultural location theory, industrial layout theory, and new economic geography theory. It constructs a theoretical analysis framework regarding natural resource endowment, urbanization level, and transportation conditions (see Figure 1).

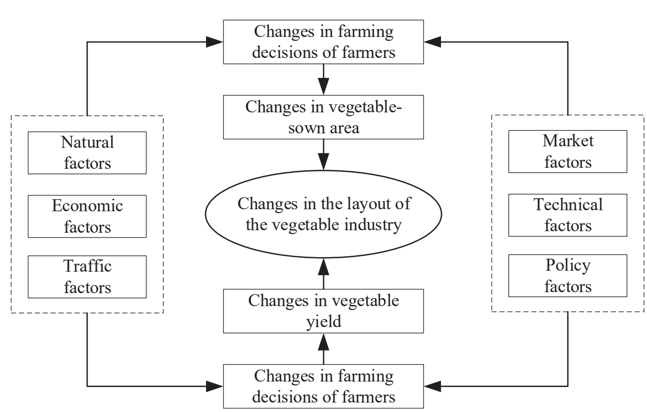


Figure 1. Research framework.

(1) Vegetable cultivation is subject to the dual constraints of natural resources and natural disasters. China is a vast country with large differences in resource endowments among regions, and vegetable cultivation requires suitable natural conditions such as temperature, precipitation, sunshine hours and irrigation; conversely, agriculture is weak and vulnerable to natural disasters, and the occurrence of natural disasters such as floods, droughts and vegetable pests and diseases can reduce vegetable yields and affect farmers' planting decisions in the following year, thus leading to changes in vegetable planting areas and products. Therefore, this paper takes natural conditions as the primary factor influencing the shift in vegetable production layout, and natural resources are expected to positively impact the layout structure of the vegetable industry. In contrast, natural disasters are to negatively impact the layout of vegetable production.

(2) With the development of the economy, the urbanization process is accelerating, non-farm employment opportunities are increasing, part-time employment is becoming more prominent, a large number of rural laborers are moving to the cities, the opportunity cost of farmers increases, and the accelerated urbanization process is likely to make farmers lack comparative advantage in vegetable farming. Therefore, farmers will adjust their vegetable planting decisions after weighing the income from vegetable planting and non-farm income, thus causing changes in vegetable planting scale and production.

(3) Location theory believes that transportation cost plays a key role in the location choice of economic activities, and convenient transportation conditions can reduce transportation costs and promote the rational layout of the agricultural industry. Vegetables have high water content, short shelf life, and are highly perishable; conversely, residents have extremely high requirements for the freshness of vegetables. This determines that only convenient transportation conditions and developed transportation facilities can realize long-distance transportation and sales of vegetables. In addition, the continuous improvement of transportation conditions is an important driving factor for the restructuring of agricultural production [25]. Therefore, the development of transportation infrastructure has become an important factor in the current changes in the layout of the agricultural output.

(4) Market demand has a vital role in promoting the change in vegetable production layout. Along with the deepening of market-oriented reform, people's living standards have improved, food consumption demand has gradually changed from subsistence to quality, and vegetable production is increasingly influenced by market demand.

(5) The vegetable industry is not only labor intensive but also technology intensive. As agricultural technology improves the yield of different crops to different degrees, it may affect the comparative returns of vegetable cultivation, which in turn affects the motivation of vegetable farmers to cultivate vegetables, thus making changes in the scale and yield of vegetable production. In addition, there are regional differences in technological advances in vegetable cultivation, which have different effects on the layout of vegetable production.

(6) From Porter's diamond model, it is known that the development of an industry cannot be separated from the support of government policies. The government provides farmers with subsidies, credit, and information related to vegetable production will greatly increase farmers' motivation to grow vegetables, thus affecting the changes in vegetable cultivation scale and output.

3. Data Sources and Research Methodology

3.1. Data Sources

In the analysis of the characteristics of the changing layout of vegetable production in China, this paper uses the data on vegetable-sown area and production by province in China from 2010 to 2019 for spatial visualization, and the data are obtained from the China Rural Statistical Yearbook. In the analysis of the drivers of changes in the layout of vegetable production in China, the data sources of the variables used in this paper are as follows.

3.2. Study Variables

3.2.1. Explained Variables

To explore the changes layout of vegetable production in this paper, the current study used the proportion of vegetable-sown area in each province to the total vegetable planted area in the country and the proportion of vegetable output in each region to the total vegetable output in the country as a proxy variable.

3.2.2. Explanatory Variables

The explanatory variables employed in the study include natural factors, economic factors, transportation factors, market factor, technology factor and policy factor.

(1) Natural factors: In this paper, the indicators of effective irrigated area, affected area, temperature, precipitation and sunshine hours are selected as proxy variables for the natural factors of changes in vegetable production layout. The data on the effective irrigated area, and the affected area of vegetables are obtained by estimation. The specific calculation methods are as follows: effective irrigated area of vegetables = effective irrigated area of crops × (vegetable-sown area ÷ total sown area of crops); affected area of vegetables = affected area of crops × (vegetable-sown area ÷ total sown area of crops), and to ensure data stability, these variables are treated as logarithms in this paper. The data of effective irrigated area and total sown area of crops are obtained from the official website of National Bureau of Statistics (https://data.stats.gov.cn), and the area of crops affected and vegetable-sown area are obtained from China Rural Statistical Yearbook. Climate data on temperature, precipitation and sunshine from the National Meteorological Information Center—China Meteorological Data Network (http://data.cma.cn).

(2) Economic factors: The level of urbanization is an important indicator of regional economic development and the proportion of urban population to total population is used to indicate the level of urbanization in the region. These data are obtained through the official website of the National Bureau of Statistics (https://data.stats.gov.cn).

(3) Traffic factors: We used the road density as a proxy variable for the traffic factor, which is expressed as the ratio of road mileage in each province to the administrative area of that province. The road mileage data are obtained from the official website of the National Bureau of Statistics (https://data.stats.gov.cn).

(4) Market factors: In order to reflect the market demand of different provinces, this paper adopts retail sales of social consumer goods as the proxy variable of vegetable market demand, and in order to eliminate the influence of non-smoothness of data on the empirical results, this paper legalizes it, and the data are obtained from the China Rural Statistical Yearbook.

(5) Technical factors: With the continuous innovation and promotion of agricultural technology, the level of vegetable yields continues to improve. In this paper, the total power of agricultural machinery is used as a proxy variable for technological progress in agriculture. The data are obtained through the official website of the National Bureau of Statistics (https://data.stats.gov.cn).

(6) Policy factors: The government's financial support policy for agriculture will make farmers more motivated to grow vegetables. In this paper, the share of local fiscal expenditure on agriculture, forestry, and water affairs in local fiscal general budget expenditure is used to indicate the financial support policy for agriculture. The data on local fiscal spending on agriculture, forestry, and water affairs and local fiscal general budget expenditure were obtained from the official website of the National Bureau of Statistics (https://data.stats.gov.cn). Table 1 reports the definitions and descriptive statistics results of each variable.

Table 1. Description and summary statistics of the studied variables.

Variables	Symbols	Definition	Mean	Standard Deviation
Area weight	Area	Sown area by province ÷ total national sown area	0.0323	0.0253
Yield weight	Yield	Production by province ÷ Total national production	0.0323	0.0307
Effective irrigated area for vegetables	LnAeff	Effective irrigated area of crops × (vegetable-sown area ÷ total sown area of crops)	5.1506	1.0288
Vegetables affected area	LnAaff	Crop affected area × (vegetable-sown area ÷ total crop sown area)	3.9073	1.4427
Temperature	LnTem	Average temperature by province	2.5442	0.3951
Precipitation	LnPre	Average precipitation by province	9.0611	0.5007
Sunshine hours	LnSun	Average daylight hours by province	7.6037	0.2579
Urbanization level	Urban	Number of urban populations ÷ total population	0.5551	0.1355
Road density	Traf	Road mileage ÷ administrative area	0.8962	0.5098
Market demand	LnMark	Retail sales of social consumer goods	8.6722	1.0936
Technological advances	LnTech	Total power of agricultural machinery	7.6264	1.1162
Financial support for agriculture expenditure	Fina	Local finance expenditure on agriculture, forestry and water affairs ÷ Local finance general budget expenditure	0.1152	0.0325

3.3. Research Methodology

3.3.1. Standard Deviational Ellipse (SDE)

Unlike the previous studies, who used the production concentration index, Herfindahl–Hirschman index, dispersion in probability statistics, and locational entropy, standard deviational ellipse to characterize the spatial aggregation of vegetable production in China, the current paper used the Standard Deviational Ellipse to reveal the spatial agglomeration characteristics of vegetable production, proposed by Lefever [26], which can accurately show the spatial distribution and spatial and temporal evolution of geographical factors. The main advantage of ellipse distribution range is that it can broadly indicate the main area of vegetable production distribution in China, the mean center can describe the center of gravity of vegetable production layout and indicate the relative position of vegetable production distribution in China, the azimuth reflects the main trend direction of vegetable production distribution in China, the long half-axis characterizes the main distribution direction of vegetable production, and the short half-axis the dispersion degree of vegetable production [27,28], which can be calculated by Equations (1)–(4).

$$\overline{X_w} = \frac{\sum_{i=1}^{n} w_i x_i}{\sum_{i=1}^{n} w_i}, \overline{Y_w} = \frac{\sum_{i=1}^{n} w_i y_i}{\sum_{i=1}^{n} w_i} \tag{1}$$

$$\sigma_x = \sqrt{\frac{\sum_{i=1}^{n} (w_i \overline{x_i} \cos\theta - w_i \overline{y_i} \sin\theta)^2}{\sum_{i=1}^{n} {w_i}^2}} \tag{2}$$

$$\sigma_y = \sqrt{\frac{\sum_{i=1}^{n} (w_i \overline{x_i} \sin\theta - w_i \overline{y_i} \cos\theta)^2}{\sum_{i=1}^{n} {w_i}^2}} \tag{3}$$

$$\tan\theta = \frac{\left(\sum_{i=1}^{n} {w_i}^2 {\overline{x_i}}^2 - \sum_{i=1}^{n} {w_i}^2 {\overline{y_i}}^2\right) + \sqrt{\left(\sum_{i=1}^{n} {w_i}^2 {\overline{x_i}}^2 - \sum_{i=1}^{n} {w_i}^2 {\overline{y_i}}^2\right)^2 + 4\sum_{i=1}^{n} {w_i}^2 {\overline{x_i}}^2 {\overline{y_i}}^2}}{2\sum_{i=1}^{n} {w_i}^2 \overline{x_i}\overline{y_i}} \tag{4}$$

Where (X_i, Y_i) is the spatial coordinate of the study area; $(\overline{X_i}, \overline{Y_i})$ is the relative coordinate of (X_i, Y_i) from the center of the distribution; w_i denotes the weight; θ is the azimuth of the standard deviation ellipse, i.e., the angle of clockwise rotation in the due north direction to the long axis of the standard deviational ellipse; σ_x and σ_y denote the standard deviation on the x and y axes, respectively. At present, this method has been widely used in economics. Meanwhile, this paper draws on the spatial agglomeration degree calculation method of Zhao L. and Zhao Z. to calculate the spatial agglomeration degree of China's vegetable industry [28], which is spatially agglomerated if the vegetable distribution ellipse area is significantly larger (or smaller) than the benchmark distribution ellipse. The formula for calculating the spatial agglomeration degree is A = | 1− [Area(vegetable industry distribution ellipse)/Area(benchmark distribution ellipse)] | .

3.3.2. Exploratory Spatial Data Analysis Method (ESDA)

To further investigate the spatial agglomeration characteristics and spillover effects, the spatial correlation of vegetable production agglomeration in China was examined by using the global and local spatial correlation indices in Exploratory Spatial Data Analysis (ESDA). The global spatial correlation is measured by Moran's I index, which is calculated by Moran [29] and Anselin [30]. Local spatial correlations and spatial clustering characteristics are described by plotting Moran's scatter plot. The weight matrix used in this paper is the economic, spatial weight matrix (W), where i and j represent cell i and j, respectively, E is a matrix describing the inter-regional variability, and y_{it} is the actual regional value added of the primary industry in the ith province in year t, calculated as $E_{ij} = 1/\left|\overline{y}_i - \overline{y}_j\right|$, $E_{ii} = 0$, $\overline{y}_i = 1/t_1 - t_0 + 1\sum_{t=t_0}^{t_1} y_{it}$.

3.3.3. Spatial Durbin Model (SDM)

Following the notion of LeSage and Pace [31], the Spatial Durbin Model (SDM) is constructed, which considers the spatial spillover effects of both the explained and explanatory variables and solves the problems of variable omission and endogeneity to a certain extent, and the general form of the model is set as follows.

$$Y = \alpha Z_n + \rho WY + \beta X + \theta WX + \varepsilon \tag{5}$$

In Equation (5), the explanatory variable Y denotes the change in the layout of vegetable production; the α is a constant term, Z_n is the $N \times 1$ unit matrix, N is the number of provinces, W is the economic spatial weight matrix, X represents the explanatory variables, WY and WX consider the spatial dependence of the explained and explanatory variables, respectively, and ε is the model error term.

To ensure the robustness of the estimation results, following the idea of Elhorst [32], the current study applies the Wald test to discern whether the spatial Durbin model can be transformed into a Spatial Lag Model (SLM) and a Spatial Error Model (SEM). If the test results significantly reject the original hypothesis, then the spatial Durbin model is better than the SLM and the SEM.

4. Results

4.1. Spatial Distribution and Spatial Trends of Chinese Vegetable Industry

To visually demonstrate the characteristics of the changing layout of Chinese vegetable production, this paper draws the spatial distribution pattern of the vegetable-sown area and production in 2010 and 2019 based on ArcGIS geostatistical software as shown in Figure 2.

It can be seen from the figure that the development of China's vegetable industry shows obvious spatial non-equilibrium characteristics. China's vegetable planting was mainly located in Shandong and Henan provinces in 2010; while in 2019, the main vegetable planting provinces added Jiangsu and Sichuan provinces, and the planting area was also expanded. Comparatively 2010, the overall growth of vegetable production in 2019 increased specifically in the areas of Shandong, Henan, and other large agricultural areas. Overall, the regional differences in the development of China's vegetable industry are more obvious; the development of the vegetable industry in the eastern and south region is better than the western and northern region, respectively, which reveals the importance of exploring spatial synergy.

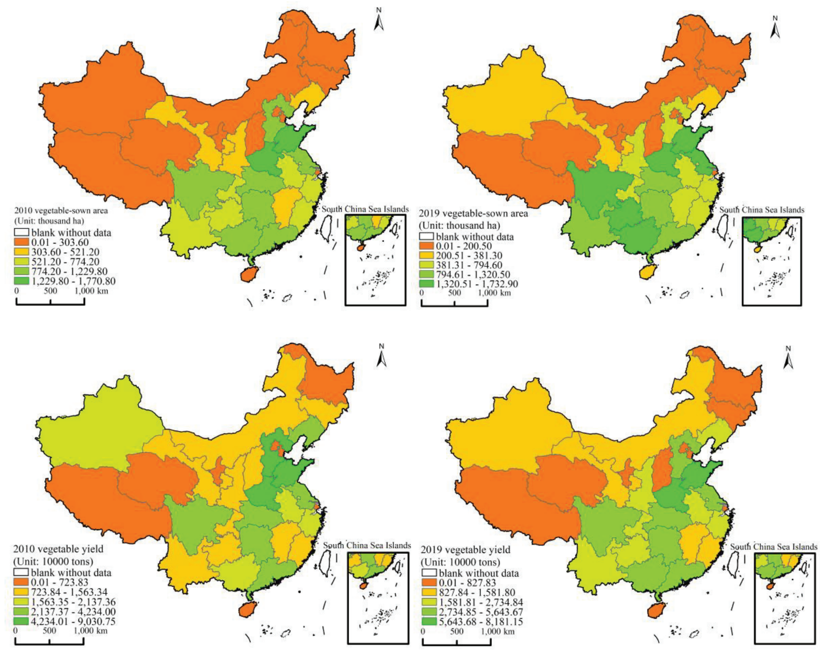


Figure 2. Spatial distribution pattern of vegetable-sown area and yield in China.

The study further presented the trend graphs of vegetable sowing area and yield in 2010 and 2019 by using the global trend analysis method of ArcGIS geostatistical analysis. The outcome reveals that the vegetable-sown area and yield in 2010 and 2019 were produced with due east and due north directions as the X and Y axes and vegetable-sown area and production as the height attribute values (Z-axis), respectively (see Figure 2). Figure 3a,b shows that the vegetable-sown area in China offers an obvious inverted U-shaped trend in the east–west and north–south directions. The east is higher than the west, and the south is higher than the north. Likewise, the inverted U-shaped characteristic of the projected trend line of vegetable production is more moderate, and the east is higher than the west, which is still obvious as shown in Figure 3c,d. From the above results, it is apparent that both vegetable-sown area and vegetable production in China in 2019 showed an increase compared to 2010, and the inverted U-shaped characteristics of vegetable planted area in the spatial trend are also found to be more apparent compared to vegetable production.

4.2. Spatial Aggregation and Evolution of Chinese Vegetable Industry

Based on the spatial visualization description of the distribution of vegetable area and yield in China, to further reveal the spatial agglomeration characteristics of the Chinese vegetable industry, this paper also explored the spatial agglomeration characteristics of the Chinese vegetable industry using two methods: standard deviation ellipse and exploratory spatial data analysis. The standard deviation ellipse of vegetable-sown area and production in China are shown in Figure 4. According to Figure 4a, the center of gravity of the ellipse distribution of vegetable-sown area in China is located in Hubei. It keeps moving to the southwest over time. Moreover, the long and short half-axes of the standard deviation ellipse are significantly shorter in 2019, and the shape is more flattened as compared to previous years. Furthermore, Figure 4b shows that the standard deviation ellipse of vegetable production in China is more toward the northeast than that of the sown area ellipse, and the center of gravity of the distribution also shows a trend of moving toward southwest. Unlike the vegetable planted area, the vegetable yield ellipse distribution centers are all located in Henan. Especially obvious is that the azimuth of the vegetable yield ellipse in 2019 is 37.46°, showing a greater angle of clockwise rotation as compared to other years.

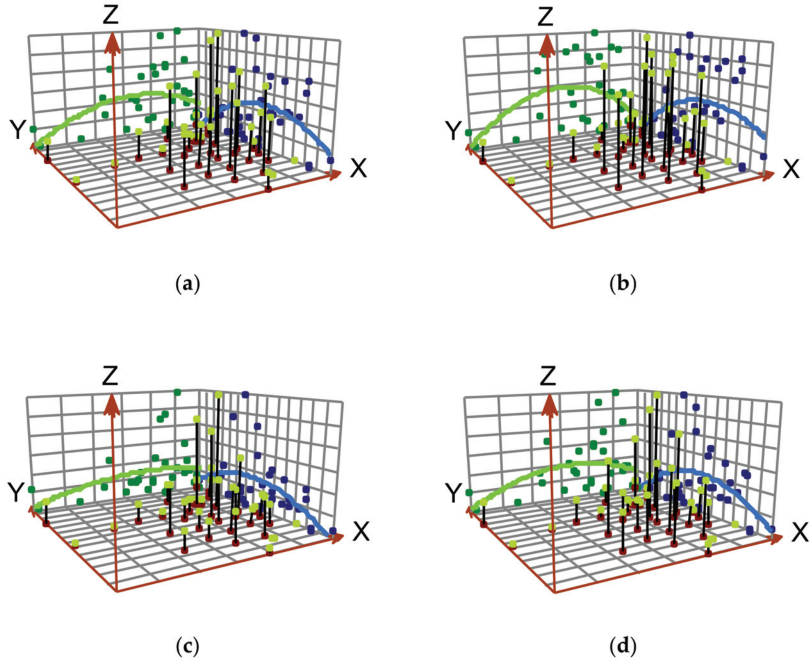


Figure 3. Spatial trend map of vegetable-sown area and yield in China. (**a**) 2010 vegetable-sown area; (**b**) 2019 vegetable-sown area; (**c**) 2010 vegetable yield; (**d**) 2019 vegetable yield.

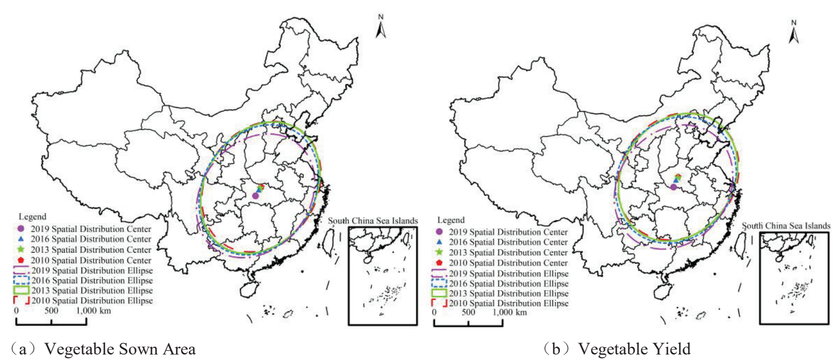


Figure 4. Standard deviation ellipse of vegetable-sown area and yield in China: (**a**) vegetable-sown area; (**b**) vegetable yield.

Furthermore, the outcome in Table 2 shows that the spatial aggregation of vegetable-sown area in China fluctuates, with a slight decrease in 2013 compared to 2010, but an increase in 2016, with the highest spatial accumulation of 0.47 in 2019, while the spatial aggregation of vegetable production is on the rise, gradually increasing from 0.41 in 2010 to 0.44 in 2019; the sown area shows stronger spatial clustering characteristics. In terms of the evolution of spatial clustering, the long half-axis of the ellipse of vegetable-sown area distribution shortened from 983.67 km in 2010 to 958.32 km in 2019, and the short half-axis shortened from 795.54 km in 2010 to 763.66 km in 2019, which reflects the obvious spatial clustering characteristics of vegetable-sown area in the northeast-southwest direction. In summary, the test results based on the standard deviation ellipse method show obvious spatial clustering characteristics in Chinese vegetable production. The centers of gravity of the vegetable sowing area and production in China are located in Hubei and Henan, respectively. From 2010 to 2019, the centers of gravity of the vegetable sowing area and production gradually move to the southwest, indicating that the center of output has slowly steadily moved from the north to the south as the future development trend of the Chinese vegetable industry.

Table 2. Standard deviation ellipse-related parameters of the Chinese vegetable industry.

Categories	Year	Short Half Shaft (km)	Long Half Shaft (km)	Azimuth (°)
Area	2010	795.54	983.67	31.85
	2013	783.22	1001.51	32.73
	2016	789.79	987.90	33.28
	2019	763.66	958.32	38.85
Yield	2010	838.09	973.82	35.76
	2013	812.27	983.91	34.20
	2016	834.54	967.10	35.49
	2019	801.15	965.55	37.46
Categories	**Year**	**Center Coordinates**	**Spatial Aggregation**	**Distribution of the Direction of Movement of the Center of Gravity**
Area	2010	112.59° E, 32.00° N	0.44	-
	2013	112.40° E, 31.87° N	0.43	Southwest
	2016	112.13° E, 31.62° N	0.44	Southwest
	2019	111.59° E, 30.89° N	0.47	Southwest
Yield	2010	113.37° E, 33.87° N	0.41	-
	2013	113.33° E, 33.76° N	0.42	Southwest
	2016	112.92° E, 33.44° N	0.42	Southwest
	2019	112.46° E, 32.53° N	0.44	Southwest

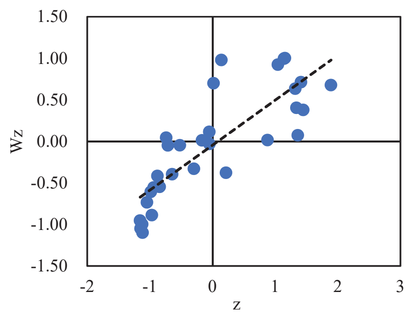
Further, the results of the region-wide spatial correlation test showed that under the economic, spatial weight matrix, the Moran's I indices of the vegetable area and production in China were greater than 0 (see Table 3), indicating that the distribution of vegetable production in China exhibited positive spatial correlation characteristics of high-high agglomeration (High-High type, H-H type) and low-low agglomeration (Low-Low type, L-L type). In other words, there is a mutual influence on the development of the vegetable industry in each province, i.e., there is a significant positive spatial dependence. This outcome is consistent with the previous study of Ji et al. [3].

Figure 5 reports the Moran scatter plot of vegetable-sown area and production in China in 2019, it can be seen from the figure that Chinese vegetable production shows a positive spatial correlation, with the 2019 vegetable area scatter plot revealing that 12 provinces are located in the first quadrant (high-high agglomeration) and the third quadrant (low-low agglomeration), respectively. Likewise, the 2019 vegetable production scatter plot shows that a total of eight provinces and a total of 18 regions located in the third quadrant, i.e., most of the provinces are located in the first and third quadrants, indicating that there are obvious spatial agglomeration characteristics of vegetable production in China, i.e., the spatial distribution of vegetable production in China is non-homogeneous. There is a significant positive spatial spillover effect.

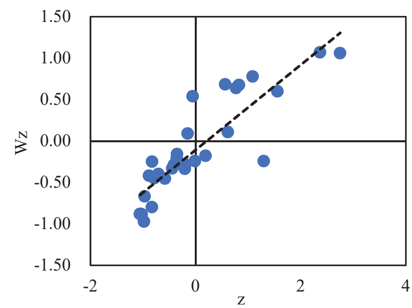
Table 3. Moran's I index of the Chinese vegetable industry.

Year	Vegetable-Sown Area		Vegetable Yield	
	I	z	I	z
2010	0.579 ***	5.272	0.429 ***	4.236
2011	0.585 ***	5.313	0.434 ***	4.260
2012	0.590 ***	5.331	0.440 ***	4.293
2013	0.589 ***	5.313	0.441 ***	4.290
2014	0.591 ***	5.317	0.443 ***	4.314
2015	0.592 ***	5.325	0.450 ***	4.369
2016	0.596 ***	5.345	0.459 ***	4.440
2017	0.546 ***	4.909	0.501 ***	4.732
2018	0.536 ***	4.818	0.506 ***	4.750
2019	0.541 ***	4.858	0.514 ***	4.799

Note: *** indicate 1% significance levels.



(**a**)



(**b**)

Figure 5. Moran scatter plot of vegetable planting area and yield: (**a**) 2019 vegetable-sown area; (**b**) 2019 vegetable yield.

In addition, the movement of the center of gravity of vegetable production in China is also plotted (see Figure 6) based on the coordinates of the ellipse center of the standard deviation of the Chinese vegetable industry calculated in the previous section. It is apparent from the figure that compared to 2010, the vegetable-sown area in 2019 showed a trend of moving to the southwest with an azimuthal change of 7°. The ellipse center shifted from Zaoyang City, Xiangyang City, Hubei Province (112.59° E, 32.00° N) to Yuan'an County, Yichang City, Hubei Province (111.59° E, 30.89° N), with a total of 155.67 km in the southwest distance. From the standard deviation ellipse parameters of vegetable production, the long and short semi-axes of the ellipse showed an overall shortening trend (the short semi-axis of the ellipse increased slightly in 2016 compared with 2013), the spatial agglomeration rose from 0.41 in 2010 to 0.44 in 2019, the azimuthal angle changed by 1.7°, and the center of gravity of distribution shifted 12.78 km to the southwest from 2010 to 2013 (from Jia County, Pingdingshan City, Henan Province to Weidong County, Pingdingshan City, Henan Province), 52.04 km to the southwest from 2013 to 2016 (from Weidong County, Pingdingshan City, Henan Province to Fangcheng County, Nanyang City, Henan Province), and 109.91 km to the southwest from 2016 to 2019 (from Fangcheng County, Nanyang City, Henan Province to Xinye County, Nanyang City, Henan Province). This shows that the trend of agglomeration in the distribution of vegetable production in China is becoming more and more obvious, and the center of gravity has accelerated in the southwestern direction.

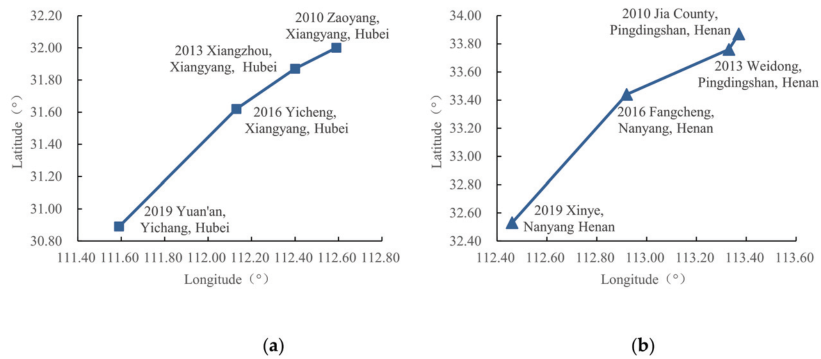


Figure 6. Shift chart of vegetable production center in China: (**a**) vegetable-sown area; (**b**) vegetable yield.

To reveal the evolutionary trend of spatial aggregation of vegetable production in China in more detail, this paper reported the changes in H-H provinces in 2010, 2013, 2016, and 2019 in the context of vegetable area and vegetable production (see Table 4). In the context of vegetable area, Guizhou replaced Fujian to join the H-H provinces in 2013, and Chongqing was added in 2016. In 2019, Yunnan became a new member of the H-H areas. In the context of vegetable production, it was found that Liaoning dropped out of the H-H provinces in 2013 and continued to do so in 2016, while in 2019, Anhui also dropped out of the H-H regions "club". The above findings show that both at the level of vegetable area and vegetable production, "H-H" provinces are mostly distributed in eastern and central provinces, such as Shandong, Henan, Jiangsu, Anhui, Hubei, etc., and show a trend of moving to the southwest, which coincides with the direction of moving the center of the standard deviation ellipse distribution in the previous paper, indicating that Chinese vegetable production shows an overall trend of moving to the southwest.

Table 4. Change in "high-high" type of provinces.

Categories	2010	2013	2016	2019
Area	Shandong, Henan, Jiangsu, Anhui, Hubei, Hunan, Fujian, Guangxi, Guangdong, Sichuan	Shandong, Henan, Jiangsu, Anhui, Hubei, Hunan, Guizhou, Guangxi, Guangdong, Sichuan	Shandong, Henan, Jiangsu, Anhui, Hubei, Hunan, Guizhou, Guangxi, Guangdong, Chongqing, Sichuan	Shandong, Henan, Jiangsu, Anhui, Hubei, Hunan, Yunnan, Guizhou, Guangxi, Guangdong, Chongqing, Sichuan
Yield	Shandong, Henan, Jiangsu, Anhui, Hubei, Hunan, Guangxi, Guangdong, Liaoning, Sichuan	Shandong, Henan, Jiangsu, Anhui, Hubei, Hunan, Guangxi, Guangdong, Sichuan	Shandong, Henan, Jiangsu, Anhui, Hubei, Hunan, Guangxi, Guangdong, Sichuan	Shandong, Henan, Jiangsu, Hubei, Hunan, Guangxi, Guangdong, Sichuan

4.3. Analysis of Driving Factors of Changing Layout

To explore the driving factors accountable for changing vegetables layout patterns in China, the current study employed the spatial Durbin model (see Table 5). According to the findings, it is seen that both Wald-spatial-lag and Wald-spatial-error tests reject the original hypothesis at the 1% significance level, i.e., the spatial Durbin model could not be converted into a lagged model and a spatial error model. The findings further reveal that the share of vegetable-sown area in each province with respect to the country's total vegetable-sown area, the Log-likelihood value of the fixed-effect model is found at 1389.54, which is higher than that of the random-effect model (1305.07).

Table 5. Estimation results of spatial Durbin model.

Variables	Area		Yield	
	FE	**RE**	**FE**	**RE**
LnEffe	0.0164 *** (12.19)	0.0148 *** (11.02)	0.0162 *** (10.28)	0.0163 *** (10.25)
LnAffe	0.0002 (0.81)	0.0002 (0.69)	0.0004 (1.28)	0.0005 (1.54)
LnTem	−0.0008 (−0.09)	0.0043 (0.80)	−0.0017 (−0.17)	0.0069 (0.91)
LnPre	0.0023 (1.04)	0.0039 * (1.83)	0.0049 * (1.90)	0.0053 ** (2.03)
LnSun	0.0017 (0.42)	−0.0021 (−0.55)	0.0037 (0.78)	0.0031 (0.65)
Urban	−0.0431 *** (−2.93)	−0.0383 *** (−3.26)	−0.0819 *** (−4.74)	−0.0745 *** (−4.78)
Traf	−0.0099 *** (−2.73)	−0.0038 (−1.26)	−0.0124 *** (−2.98)	−0.0048 (−1.18)
LnMark	0.0009 (0.45)	0.0023 (1.25)	0.0057 ** (2.28)	0.0073 *** (3.08)
LnTech	0.0035 *** (2.70)	0.0027 ** (2.28)	0.0030 ** (2.00)	−0.0040 *** (2.64)
Fina	0.0020 (0.11)	−0.0027 (−0.16)	−0.0025 (−0.13)	−0.0021 (−0.10)
W(LnEffe)	−0.0043 * (−1.84)	−0.0022 * (−0.94)	−0.0004 (−0.14)	−0.0014 (−0.51)
W(LnAffe)	−0.0012 ** (−2.58)	−0.0012 ** (−2.39)	−0.0011 ** (−1.95)	−0.0011 * (−1.88)
W(LnTem)	−0.0151 (−1.19)	−0.0183 ** (−2.00)	−0.0147 (−0.99)	−0.0294 ** (−2.24)
W(LnPre)	−0.0039 (−1.38)	−0.0052 ** (−1.82)	−0.0070 ** (−2.10)	−0.0079 ** (−2.30)
W(LnSun)	0.0037 (0.67)	0.0088 (1.59)	0.0016 (0.24)	0.0057 (0.85)
W(Urban)	−0.0134 (−0.54)	−0.0366 ** (−1.97)	0.0916 *** (3.12)	0.0539 ** (2.18)
W(Traf)	0.0460 *** (7.27)	0.0504 *** (8.95)	0.0273 *** (3.67)	0.0330 *** (4.57)
W(LnMark)	−0.0032 (−1.01)	−0.0044 * (−1.76)	−0.0094 ** (−2.58)	−0.0100 *** (−2.99)
W(LnTech)	0.0006 (0.30)	0.0022 (1.26)	0.0017 (0.73)	0.0023 (1.05)
W(Fina)	0.0518 (1.52)	0.0393 (1.14)	0.0270 (0.67)	0.0277 (0.67)
ρ	0.2022 ***	0.1903 ***	0.0876	0.1569 *
AIC	−2735.09	−2562.13	−2637.66	−2436.35
Log likelihood	1389.54	1305.07	1340.83	1242.18
Wald-spatial-lag	82.90 ***	113.95 ***	50.72 ***	62.33 ***
Wald-spatial-error	65.63 ***	99.44 ***	42.45 ***	51.00 ***

Note: ***, **, and * indicate 1%, 5%, and 10% significance levels, respectively.

Further, with the share of vegetable production of each province with respect to the total national vegetable production, the Log-likelihood value of the fixed effects model is 1340.83, higher than the random-effects model (1242.18), and the AIC values of both fixed-effects models are lower than the random-effects model, indicating that the fixed effect of the spatial Durbin model is more appropriate. The results further show that the coefficient of the spatial lag term of the share of vegetable-sown area in each province to the total vegetable planted area in the country is 0.2022, which is highly significant at the 1% level. The coefficient of the spatial lag term of the share of vegetable production in each province to the total vegetable production in the country is 0.0876, indicating the interdependence of vegetable production between regions.

According to Lesage and Pace [31], if the coefficient of the spatial lag term of the explanatory variable $\neq 0$, it cannot directly explain the economic significance of each variable. Accordingly, this paper further decomposes the spatial spillover effect into direct effect (intra-regional spillover), indirect effect (inter-regional spillover), and total effect (average effect of changes in the explanatory variables on all regions) through the partial differencing method of the spatial regression model, and the estimation results are detailed in Table 6.

Table 6. Decomposition results of spatial effects.

Variables	Area			Yield		
	Direct Effect	**Indirect Effects**	**Total Effect**	**Direct Effect**	**Indirect Effects**	**Total Effect**
LnEffe	0.0164 *** (11.97)	−0.0013 (−0.53)	0.0151 *** (5.65)	0.0163 *** (10.10)	0.0010 (0.40)	0.0173 *** (6.18)
LnAffe	0.0002 (0.61)	−0.0013 ** (−2.24)	−0.0012 * (−1.72)	0.0004 (1.23)	−0.0011 * (−1.67)	−0.0006 (−0.93)
LnTem	−0.0007 (−0.09)	−0.0202 (−1.45)	−0.0209 ** (−1.98)	−0.0010 (−0.11)	−0.0180 (−1.17)	−0.0190 * (−1.75)
LnPre	0.0021 (1.01)	−0.0041 (−1.35)	−0.0020 (−0.74)	0.0047 * (1.91)	−0.0070 ** (−2.10)	−0.0022 (−0.82)
LnSun	0.0018 (0.48)	0.0049 (0.80)	0.0067 (1.17)	0.0036 (0.82)	0.0021 (0.31)	0.0057 (0.96)
Urban	−0.0434 *** (−3.04)	−0.0270 (−0.91)	−0.0705 ** (−2.27)	−0.0794 *** (−4.61)	0.0911 *** (2.91)	0.0117 (0.36)
Traf	−0.0079 ** (−2.13)	0.0538 *** (6.38)	0.0460 *** (4.58)	−0.0119 *** (−2.80)	0.0287 *** (3.45)	0.0168 * (1.65)
LnMark	0.0007 (0.37)	−0.0036 (−1.06)	−0.0029 (−0.90)	0.0054 ** (2.32)	−0.0097 *** (−2.61)	−0.0043 (−1.27)
LnTech	0.0036 *** (2.94)	0.0014 (0.61)	0.0050 ** (2.06)	0.0032 ** (2.19)	0.0019 (0.78)	0.0051 ** (2.02)
Fina	0.0049 (0.29)	0.0640 (1.61)	0.0689 (1.62)	−0.0015 (−0.07)	0.0301 (0.71)	0.0287 (0.65)

Note: ***, **, and * indicate 1%, 5%, and 10% significance levels, respectively.

The results reveal that the direct effect of effective irrigation area (LnEffe) on the layout of vegetable production was positive at 1% significance level, indicating that effective irrigation of vegetables in the region significantly contributes to an increase in the share of vegetable-sown area and production in the region. The results in the context of indirect effects are found to be small, and none of them passed the significance level test, indicating that the increase in effective irrigated area in this region had little effect on the increase in the share of vegetable area and production in other regions. In the context of total effects, the results are found significant. The results for the full impact are all significantly positive, implying that the intra-regional spillover effect of effective irrigated vegetable area on vegetable production layout is considerably larger than the inter-regional spillover effect. The direct effect of vegetable affected area (LnAffe) on vegetable production layout was small, 0.0002 and 0.0004, respectively, and insignificant, while the indirect effect is found to be negative and significant. Since the negative spillover effect of the vegetable affected area between regions cancels out the weak positive direct effect within regions, the final total impact is still negative, indicating that the vegetable affected area harms the layout of the vegetable industry in general. The coefficients of direct effect, indirect effect and total effect of temperature (LnTem) on vegetable area and yield share are all found negative, and the coefficient of total effect is found to be significant, indicating that temperature negatively influences the vegetable industry layout. The intra-regional spillover effect of precipitation (LnPre) on the share of vegetable-sown area and the share of vegetable production is found to be positive, indicating that abundant precipitation positively contributes to the vegetable production in the region. In contrast, the results in the context of both indirect and total effects are found to be negative. The intra-regional and inter-regional spillover effects of sunshine (LnSun) on the share of vegetable-sown area and the share of vegetable production are both found to be positive and insignificant, indicating that the sunshine factor has a positive effect on the layout of vegetable industry. The coefficients of direct effects of urbanization level (Urban) on the vegetable area and production share were -0.0434 and -0.0794, respectively, and both passed the 1% significance level test, implying that the development of local urbanization inhibits the development of local vegetable industry, which contradicts the findings of earlier study [33]. The possible reason is that the acceleration of regional urbanization makes non-farm employment opportunities increase and a large amount of rural labor flows into urban areas, causing a structural shortage of vegetable farmers. The non-farm income obtained by farmers is higher than the income from vegetable cultivation, making farmers change their cultivation decisions after weighing the benefits, thus leading to a decrease in the proportion of vegetable cultivation area and production in the region. The indirect effect of urbanization development level on the share of vegetable production is significantly positive, which infers that urbanization in the region has a positive spillover effect in increasing the vegetable yield share in other regions. It reflects the point that the increase in demand is due to the decrease in local vegetable cultivation during urbanization development. The direct effects of road density (Traf) on the vegetable area and production share are significantly negative, which is contrary to theoretical expectations, probably because transportation accessibility in the region increases vegetable distribution efficiency while also decreasing non-farm employment costs and increasing the opportunity cost of engaging in agricultural production, which has a certain negative effect on the layout of vegetable production. In contrast, the indirect effects of road density on the vegetable area and production share are found significantly positive, offsetting the negative direct effects, making the total product's effect significantly positive, and indicating that traffic accessibility has a significant positive effect on vegetable industry layout in general, this is generally consistent with the findings of the previous study [19]. The results in the case of the direct effect of market demand (LnMark) are also found to be positive, but the total indirect effects are both negative. The findings unveil that a 1% increase in local market demand will increase the share of local vegetable acreage in the national acreage by 0.0007%, and the percentage of local vegetable production in the national acreage will increase by 0.0054%. A 1% increase in local market demand will cause the proportion of vegetable planted area in other regions to the national share to decrease by 0.0036% and will also cause the proportion of vegetable production in different regions to the national share to reduce by 0.0097%, which means that the local market demand has a positive spillover effect on the local vegetable production layout and a negative spillover effect on the vegetable production layout in other regions. This is due to the fact that the vegetable growers in this region are more likely to capture local vegetable market demand information than other regions and can respond more quickly than the local vegetable market demand, thus making it more difficult for vegetable growers in different regions to squeeze out the local market. The coefficients of the intra-regional, inter-regional and total effects of technological progress (LnTech) on the share of vegetable-sown area and the share of vegetable production are all found to be positive, indicating that technological progress has a significant positive spillover effect on the layout of local vegetable production, and positive spillover to other regions. Overall, technological progress has a significant positive effect on the layout of vegetable industry. The coefficients of the direct effect, indirect effect and total effect of the effect of fiscal support policy (Fina) on the share of vegetable area are also found to be positive, but none of them pass the significance level test, indicating that the local fiscal support policy has a positive spillover effect on the layout of vegetable industry in the region and other regions, but it is not significant. The direct effect of fiscal support policy for agriculture on the share of vegetable yieldis negative (−0.0015), but the indirect and total effects are positive. Overall, the government's financial support stimulates vegetable growers' enthusiasm and influences the development of vegetable industry positively; thus, the findings propose that financial support for the vegetable industry should be enhanced in the study area.

5. Conclusions and Policy Implications

The vegetable sector is a pillar sector of any national economy, playing a vital role in increasing farmers' incomes and promoting employment, as well as transforming agriculture. Thus, to enhance vegetable production, it is of great importance to reveal the distribution and spatial agglomeration characteristics of vegetables. The study used the Chinese vegetable-sown area and production data from 2010 to 2019 to visualize the spatial distribution pattern and spatial trends of the Chinese vegetable industry. The study used ArcGIS to examine the spatial agglomeration degree and pattern of the Chinese vegetable industry using standard deviation ellipsoid technique and exploratory spatial data analysis method. The study additionally applied the spatial regression partial differential method to empirically examine the driving factors of the change in the layout of vegetable production in China. The findings reveal that the design of the Chinese vegetable industry showed strong spatial non-equilibrium characteristics during the sample period. The location distribution showed a northeast–southwest spatial pattern, showing "H-H" and "L-L" positive spatial correlation characteristics, mainly concentrated in Shandong, Henan, Hubei, and other large agricultural provinces. The center of gravity of distribution gradually moved to the southwest. The empirical regression results showed that the effective irrigated area of natural factors facilitated vegetables production layout. In contrast, the affected area had an inhibiting effect. Climate indicators such as temperature, precipitation and light show different degrees of influence on the layout of vegetable production. The direct effects of urbanization and transportation conditions on the region's layout of vegetable production are negative. Market demand has a positive spillover effect on the layout of local vegetable production, while it has a negative spillover effect on other regions. Technological progress shows positive spillover effects on the layout of vegetable production in this region and other regions, and financial support policies for agriculture as a whole also showed positive effects.

Based on the findings, the current study puts forward the following policy implications. First, it is necessary to optimize the production layout of the vegetable industry and create development policies according to local conditions. China's vegetable industry in the spatial distribution showed unbalanced characteristics; regional differences are found more pronounced. Therefore, the study reveal that we should grasp the law of changes in the layout of the vegetable industry, follow the trend of vegetable production centers moving to the southwest, pay attention to the spatial correlation of vegetable production between provinces and regions, develop differentiated policies to support the vegetable industry, and form a pattern of promoting the development of vegetable industry gradually. Second, it is imperative to accurately grasp the comparative advantages, and the development of vegetable industry agglomeration. The level of agglomeration of China's vegetable industry has gradually increased, and the characteristics of spatial agglomeration are obvious. Therefore, we should pay attention to the trend of vegetable industry distribution centers moving to the southwest, optimize industrial agglomeration policies and services, maintain the existing "H-H" type province's priority development, accelerate the low-level to high-level development, and promote the vegetable industry to areas with advantages. Third, it is necessary to strengthen vegetable technology innovation and services and promote the transformation of technical achievements. The agricultural science and technology innovation system should be improved. According to changes in market demand, the innovation of agricultural agrarian technology extension services should enhance the relevant technical inputs in the vegetable industry.

This study is not without limitation, as the current study emphasized the entire vegetable industry without considering the vegetable cultivation methods and vegetable types. Therefore, the current study proposes that future research should focus on considering the impact of different planting methods (open-air vegetables and greenhouse vegetables) on the production layout of vegetables. In addition, the changes and influencing factors of the production layout of different vegetable species should also be considered, which is conducive to developing a more targeted national policy on vegetable production.

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The Causal Pathway of Rural Human Settlement, Livelihood Capital, and Agricultural Land Transfer Decision-Making: Is It Regional Consistency?

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Abstract: Despite the increasing interest in understanding the mechanism of household livelihood decisions to increase household livelihood welfare, the combined role of livelihood capitals and human settlements in livelihood decisions is unclear. Therefore, in this paper we carried out extensive empirical research to explore the causal pathway between human settlements (including infrastructure, public services, and social governance) and livelihood capitals (including human, natural, physical, financial, and social capitals) on agricultural land transfer, taking employment choices as an intermediary factor. On this basis, this study analyzed the regional differences in the decision-making mechanisms of agricultural land transfer behaviors in eastern, central, and western regions of China through a multi-group structural equation model. The results demonstrated that capital accumulation can directly increase the possibility of agricultural land inflow ($\beta = 0.130$, $p < 0.01$), but can indirectly reduce the dependence on agricultural land by stimulating non-agricultural employment ($\beta = -0.613$, $p < 0.01$). The improvement in human settlement promotes the agricultural land inflow (outside the western region) and indirectly enhances the willingness to enter into agriculture. The employment choices play a significant mediating role by strengthening the livelihood capitals and weakening human settlements. To achieve the intense agricultural development and sustainable development of rural areas, the improvement of both rural human settlements and household livelihood capitals should be considered.

Keywords: agricultural land transfer; rural human settlement; household livelihood capital; employment choices; regional differences

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1. Introduction

Faced with the unfair positioning of rural values and the long-term isolation of urban–rural relations in China, migration is often the main employment choice for the young generations [1–3]. In 2019, nearly 170 million peasant workers left villages and settled down in cities [4]. This transfer of the agricultural labor force has triggered significant changes in resource allocation, rural land use, and labor relations [5]. Due to this massive migration, two million hectares of agriculture land fall out of production each year in China [6]. As the material basis for human social and economic activities, land resources play a crucial role by providing the space to support various rural industrial development demands [7,8]. To give full play to the production capacity of the rural industry, it is necessary to achieve mechanized-scale operation through agricultural land transfer [9,10]. Agricultural land transfer refers to a process of the reallocation and optimization of agricultural land among different management bodies [11], which aims to facilitate the transfer of surplus rural labor and improve the efficiency of land use [12].

Rural households, as the most important actors in rural areas, are the decision-makers in agricultural land transfer [13]. The sustainable livelihood framework (SLF) is widely used to understand how rural households make livelihood decisions to seek more profitable and stable livelihood strategies when faced with changes to their livelihood capitals (the resources available to households for their livelihood and development), the external environment, policies, public resources, and other conditions [14,15]. The SLF emphasizes the role of livelihood capitals in the maintenance of sustainable livelihoods [16,17]. Exploring how households form livelihood strategies and make land use and employment choices based on their livelihood capitals can enhance the understanding of large-scale intensive land use and provide insights to improve household livelihoods. Much of the current literature on agricultural land use decisions has centered on food production, water and fertilizer management, crop choices, and agricultural inputs and outputs [18–22]. Little attention has been paid to how livelihood capitals affect agricultural land transfer, and how they affect agricultural land transfer through rural employment choices.

In addition to income growth, another important motivation for rural households related to migration is to enjoy high-quality human settlements in cities [23]. Households have the tightest connections with rural human settlements, which are the sum of all facilities and services supporting household production and living [24]. Households shape rural human settlements, and the characteristics of human settlements in turn affect the livelihood decisions of the households [24,25]. Consistently, the research on rural human settlements has been focused on urban building protection, settlement characteristics, spatial patterns, and the ecological environment [24,26–29]. Relatively little research has been carried out on the mechanism of how rural human settlements affect the employment and agricultural land transfer decisions of rural households from the perspective of household willingness and satisfaction.

In this study, we construct a theoretical framework that integrates rural human settlements and household livelihood capitals to explore the causal pathway of agricultural land transfer through rural employment. In addition, regional development imbalances always exist due to natural, economic, and social reasons. The levels of effectiveness and differences in unexpected agricultural land transfer decision-making between the eastern, central, and western regions have also attracted attention, and are affected by the location, nature, resources, and economic conditions. The study is driven by the following questions: (i) How do household livelihood capitals and rural human settlements affect the livelihood decisions related to employment and agricultural land transfer, respectively? (ii) What role do employment choices play in the process of agricultural land transfer? (iii) Is the causal pathway consistent in different regions?

2. Theoretical Framework

2.1. Agricultural Land Transfer Decision-Making Process

The SLF is adopted to develop our theoretical model [16]. The SLF emphasizes the role of livelihood capitals (human, natural, physical, financial, and social capitals) in livelihood decisions because they provide households with more opportunities to diversify livelihood strategies, thereby improving their capacity to cope with shocks and enhancing their livelihood sustainability [17]. In addition, the settlement conditions also affect the agricultural labor choices and agricultural land utilization [3,30]. Improvements in infrastructure, public services, and social welfare generally impose a stabilizing effect on the development of rural settlements [24,26]. In brief, households prefer to build their houses close to available infrastructure and services [31,32], which provides an incentive for agricultural land transfer. Specifically, employment choices may serve as an intermediary in the relationship between livelihood capitals and rural human settlements vs. agricultural land transfer. For example, when the rural living environment and living funds are not enough to support their production and livelihood, most households choose to seek out employment, meaning they have to transfer the agricultural land that they have no energy to take care of. On the contrary, for farmers who choose to work and live in rural areas, the agricultural income will be a source of income that cannot be ignored.

Therefore, we develop a theoretical framework to reveal the mechanism of how household livelihood capitals and rural human settlements affect agricultural land transfer and regional differences, as shown in Figure 1.

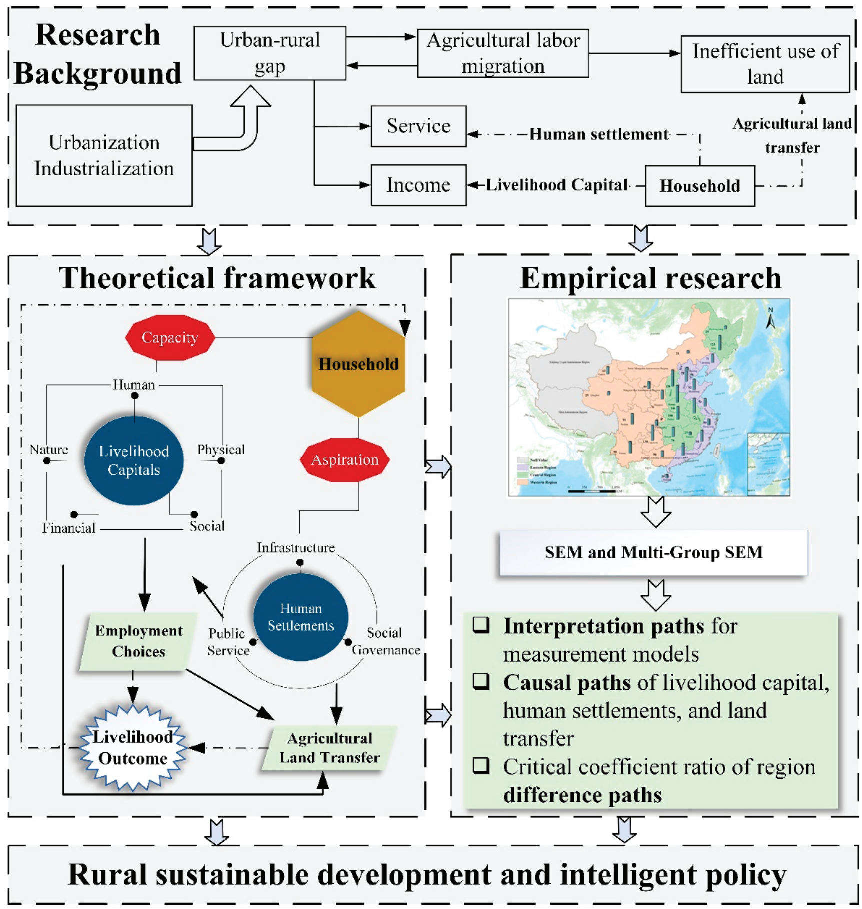


Figure 1. Agricultural land transfer decision-making process.

2.2. Dependent Variables: Agricultural Land Transfer

Faced with a dispersed and small-scale operation pattern, it is necessary to consider whether households are willing to adopt agricultural land transfer to combat the poor mechanical efficiency, wasted manpower, and increased costs caused by land fragmentation [33]. Moreover, households with no willingness or ability to farm will leave the agricultural land. In such cases, the agricultural land could be turned into financial capital through the outflow of agricultural land to achieve economic gains [34]. Thus, the agricultural land transfer is adopted as the dependent variable in this study. We use three variables to represent household agricultural land transfer: (i) which transfer behavior the household adopts; (ii) if adopted, what is the transfer area; (iii) if adopted, what is the transfer income.

2.3. Mediating Variable: Employment Choices

With the improvement in agricultural mechanization and labor productivity, the decline in the demand for agricultural labor has promoted the transfer of agricultural to non-agricultural industries [10]. Moreover, along with the acceleration of urbanization and the increase in urban employment opportunities, the non-agricultural transfer of agricultural labor continues to increase. When the economic conditions reach a certain level, the rural residents often choose to migrate to cities for better development opportunities [10]. Therefore, the employment choices of rural households can be divided into three categories, including agriculture, industry and commerce, and migratory work (Table 1).

Table 1. Mediating variables and dependent variables and indicators.

Variables	Indicators	Description/Measurement
Employment Choices	Agricultural Work	Income from agricultural production and operation (see Appendix A, No.1)
	Industrial and Commercial	Income from industrial and commercial production (see Appendix A, No.2)
	Migratory Work	Migrant workers/household size

2.4. Independent Variable: Household Livelihood Capitals

According to the SLF, an evaluation index system that measures the livelihood capital can be constructed, which includes five dimensions (human, natural, physical, financial, and social capitals) (Table 2).

Table 2. Explanatory variables and indicators.

Variables	Indicators	Measurement
Infrastructure	Medical and Health Facilities	Satisfaction level for rural medical and health care (see Table A1, No.3)
	Service Facilities	Satisfaction level for rural services for the elderly, children, and the disabled (see Table A1, No.3)
Public Service	Employment Service	Satisfaction level for community labor employment services (see Table A1, No.3)
	Social Security Services	Satisfaction level for rural social security services (see Table A1, No.3)
Social Governance	Village Committee	Will government help be sought in case of dispute? (1 = Yes, 0 = No)
	Social Governance Satisfaction	Degree of help the village committee gives to the household (see Table A1, No.4)
Human Capital	Labor Availability	Labor force/household size
	Average Education	Total education years/household size
	Medical Treatment	The annual cost of health care
Natural capital	Agricultural Land Area	Total agricultural land area owned by household
	Cultivated Land Quality	Quality of cultivated land owned by household (see Table A1, No.5)
	Agricultural Land Use Type	Types of agricultural land owned by a household (see Table A1, No.6)
Physical Capital	Homestead Area	Area of homestead owned by household
	Durable Goods	Value of durable goods (see Table A1 No.7)
	Production Assets	Value of livestock and agricultural machinery in agricultural production and operation

Table 2. *Cont.*

Variables	Indicators	Measurement
Financial Capital	Government Subsidy	Amount of government subsidy (see Table A1, No.8)
	Household Debt	Amount of household debt (see Table A1, No.9)
	Financial Assets	Amount of household financial assets (see Table A1, No.10)
Social Capital	Village Cadre	Is there a family member serving as a village cadre? (1 = Yes, 0 = No)
	Cash Gift	Amount of gift (see Table A1, No.11)
	Social Security	Amount of social security (see Table A1, No.12)

Specifically, the human capital refers to the labor ability, skills, and health status, which affect the livelihood strategies [16,35]. The variables representing human capital include labor availability, average education, and medical treatment. The development of the agricultural economy and the use of agricultural land results in the absorption and extrusion of the labor force [36]. The level of education and individual skillsets surfaced as important factors in most focus groups [37]. In addition, medical treatment constitutes an important dimension in human quality of life [17]. The natural capital represents the natural resources and services that households utilize [16], and is particularly important for households whose livelihoods rely on natural resources. Agricultural land is considered a determinant of livelihood decisions because it affects the potential income and food consumption of the household [38]. Therefore, this paper selected the agricultural land area, cultivated land quality, and agricultural land use type to represent the natural capital. The physical capital comprises the infrastructure and productive assets that facilitate household life and production [39]. It is composed of the homestead area, durable goods, and production assets in this paper. The homestead is the most important infrastructure for households [40]. Durable goods such as cars have a radical impact on the living style of the households [15,41]. Productive assets are investments made to improve the production efficiency [21,42]. The financial capital represents the financial resources that can be used to buy the goods necessary for survival and production [43]. Government subsidies, household debt, and financial assets are common sources of financial capital, which are selected in this paper. These resources provide support for livelihood activities and can be used to accumulate other livelihood assets [44]. The social capital refers to the resources that households can use to improve their livelihood capacity through social networks (such as kinship, friendship, neighbor relations), social organizations, or other groups (such as race or caste groups). It represents the social advocacy, social relations, subordination, and associations that households rely on when exploring various livelihood strategies [17]. As the most important social organization in China, the village committee helps households to enhance their livelihood [39]. The networks between relatives and friends are the primary channels for households to obtain information and assistance. Additionally, social security involves the redistribution of social resources, which is another important source of social capital [45]. Therefore, the village cadres, cash gifts, and social security are considered the evaluation variables of social capital.

2.5. Independent Variable: Rural Human Settlements

Rural human settlements can be categorized into material and non-material human settlements [24]. The infrastructure, public services, and social governance are important dimensions of rural human settlements [26,46]. The infrastructure refers to the material engineering facilities that provide convenience for the production and life of rural households [47]. Hospitals and clinics are the most basic and essential facilities needed to protect the health and life of the household [48]. Along with the elderly and children being increasingly left behind in rural areas, the infrastructure for specific groups directly affects the daily life experiences of the rural residents [49]. Therefore, medical and health facilities and service facilities are taken as the component variables of rural infrastructure conditions. Public services guarantee household participation in social, economic, political, and cultural activities [50]. Promoting employment is an important way to improve household livelihood, which is the most relevant interest of households [41,51]. Social security services can provide material help for households who temporarily or permanently lose their working ability or face living difficulties [52]. Thus, employment services and social security services are used to measure public services in this study. Social governance is necessary to maintain social order, resolve social contradictions, and promote social equity [48].

As the executive organizations and management departments responsible for village affairs, the local government and village committees assist when households face livelihood difficulties. Their main tasks are to manage rural land and other properties, undertake the production services and coordination of the village, publicize national policies, and promote rural construction. They can further create a safe living environment by mediating disputes, maintaining social order, and managing public affairs [53]. In this paper, the village committee and social governance satisfaction are selected to represent social governance.

3. Materials and Methods

3.1. Household Survey and Data Source

The dataset used to analyze rural household agriculture land transfer is taken from the China Household Finance Studies (CHFS) in 2015. The dataset is representative in terms of both the economic development and geographic location. The random sampling survey employs computer-assisted personal interviews and a comprehensive quality assurance system to strictly control the measurement errors. Because agricultural land transfer mainly occurs in rural areas, this paper restricts the sample to rural households with agricultural land or agricultural land transfer behavior. Additionally, samples with extreme housing values are also excluded. The final sample includes 2089 households and involves 148 counties and 29 provinces.

In addition, in order to explore the regional differences in the causal pathways of land transfer decisions, this study divides the samples into three groups, the eastern, central, and western regions, according to natural, economic, social, and regional conditions. Among them, the eastern region has a flat terrain, rich aquatic and mineral resources, good agricultural production conditions, and strong economic vitality. Covering many plains, the central region is a major producer of grains and is rich in mineral resources and coal reserves, allowing the rapid development of heavy industry. The overall terrain in the western region is relatively high, and it involves plateau, desert, grassland, basin, and other landforms. Due to its long periods of cold weather, water shortages, and late development, its economic development and social governance levels are relatively lagging behind. According to the regional division, there are 653, 771, and 655 households in the eastern, central, and western regions, respectively (Figure 2).

3.2. The Structural Equation Model

This paper develops a structural equation model (SEM) to investigate the pathway of agricultural land transfer, which is widely used in behavioral sciences [24,54]. It estimates the relationships between multiple factors and derives the overall fitting degree, while the measurement error of the dependent and independent variables is permitted [55]. The SEM is composed of measurement models that measure the relationships between the observable variables and latent variables and structural models that measure the possible interactions among latent variables [56]. The observable variables are the directly measured variables that contain the raw data (agricultural land area, social security services, migratory work, etc.). In contrast, the latent variables cannot be directly measured but are manifested by observable variables (human capital, infrastructure, livelihood capital, etc.). The variable of employment choices is the mediating latent variable. The equations can be shown in the following forms:

$$x = \Lambda_x \xi + \delta, \tag{1}$$

$$y = \Lambda_y \eta + \varepsilon, \quad (2)$$

$$\eta = \beta\eta + \Gamma\xi + \zeta, \quad (3)$$

where x and ξ represent the exogenous observable variables and latent variables, respectively; y and η are the endogenous observable variables and latent variables, respectively; δ and ε are the independent measurement errors; Λ_x and Λ_y are the factor loads of indices x and y on ξ and η, respectively; β is the coefficient of the interaction between endogenous latent variables; Γ is the effective coefficient measuring the effect of exogenous latent variables on endogenous latent variables, and ζ is the residual.

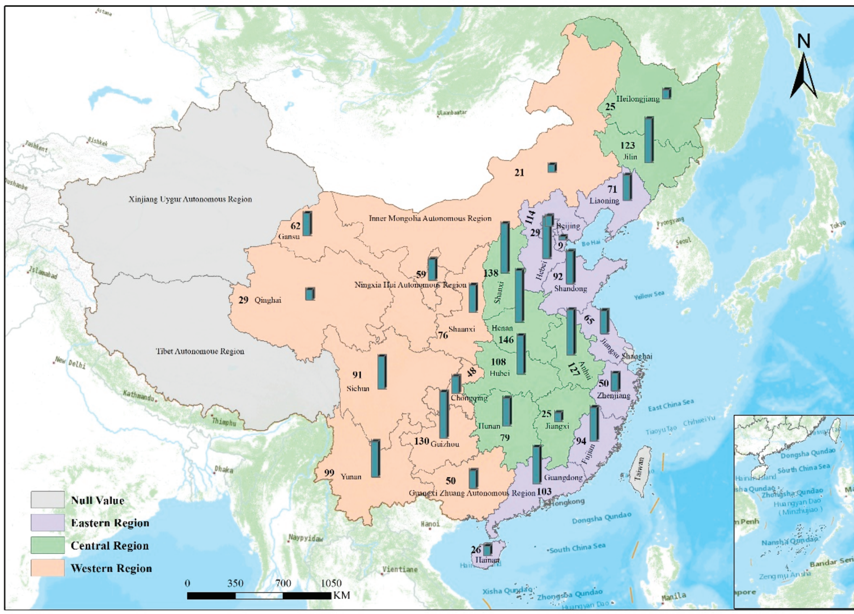


Figure 2. Distribution of household survey samples.

3.3. Multi-Group SEM

As an extension of the SEM, the multi-group SEM, is used to explore whether the research assumptions are consistent between different samples from a single scenario to a multi-group scenario [57]. The multi-group SEM includes three key steps: the inter-group invariance of the measurement model, the equivalencies of the structural model, and the analysis of difference paths [57]. The inter-group invariance of the measurement model and the equivalencies of the structural model are employed to confirm whether the causal path of the agricultural land transfer decision is statistically different at the regional scale [58]. The inter-group invariance of the measurement model is evaluated by limiting the measurement weight, structural covariances, and measurement residuals to be equal [58]. Similarly, the equivalencies of the structural model compare the differences in structural paths by constraining the measurement weight, structural weight, structural covariances, structural residuals, and measurement residuals [59]. The acceptable standard is $p > 0.05$ [59]. On this basis, the significance of the mediating effect and the path of the three regions were tested, and the results were in line with the standards [60].

4. Results

4.1. Descriptive Statistics

As shown in Figure 3, 15.31% and 12.54% of the households adopt the inflow and outflow decisions, respectively, while 4.79% of the households adopt both the inflow and outflow decisions. The mean inflow area is 1.30 mu and the mean transfer expenditure is 0.39 thousand yuan.

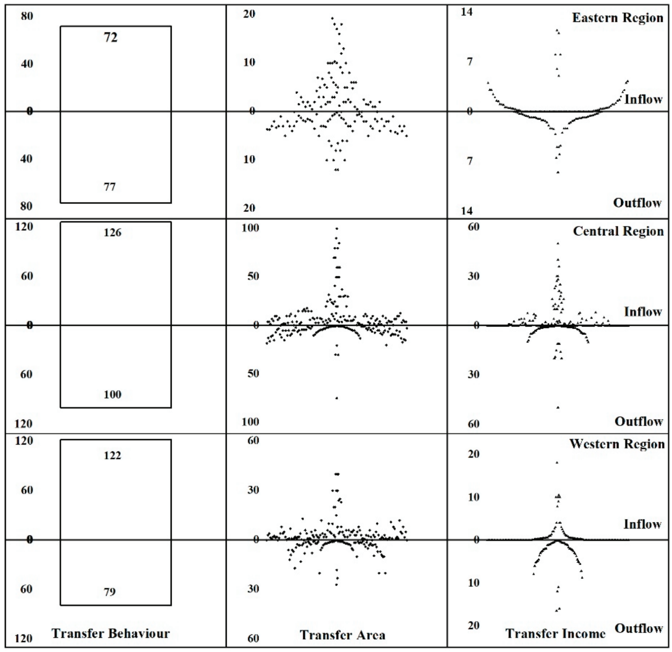


Figure 3. Descriptive statistics of dependent variables.

Regarding the mediating variables and dependent variables, the sample households overall have a mean income of 6.47 thousand yuan from agricultural work, a mean income of 16.47 thousand yuan from industrial and commercial work, and a mean percentage of 26.02% migrants (Table 3).

Table 3. The descriptive statistics for the mediating variables.

Indictor	Unit	Mean	Std. Dev	Min	Max
Agricultural Income	1000 Yuan	9.50	24.248	0.00	325.00
Industrial and Commercial Income	1000 Yuan	2.65	24.19	−500.00	300.00
Migratory work	%	27.95	20.60	0.00	100

Table 4, Figure 4a,b provide the descriptive statistics for the explanatory variables and regional differences in household livelihood and rural settlement. The data show that about 60% of the household members are contributing members, with the percentage being slightly higher in the central region. The average length of education received by household members is around 6 years, with the rate being relatively higher in the eastern region. The annual expenditure on medicines and health care for a household is 3.89 thousand yuan, which is more attributed to the western region. On average, the households only own one type of agricultural land (1.26 counts) and the quality of the cultivated land is low (average 2.90), although the type of agricultural land used in the western region and the quality of cultivated land in the eastern region have certain advantages. Traditional small-scale farming (average of 10.37 mu of agricultural land per household) increases the cost of land use and the difficulty of its management, especially in the eastern region. The household's access to physical capital shows large variations with the mean values for the homestead area (0.40 mu), durable goods (16.92 thousand yuan), and production assets (3.03 thousand yuan), being far from the maximum values. In the distribution of regional physical capitals, the advantages of the central region are reflected in the homestead area, along with the superiority of durable goods in the eastern region and production assets in the western region. Similarly, the huge difference between the mean value and the maximum value for the financial capital variables, including government subsidies, household debt, and financial assets, shows that the general economic level of the rural households is relatively low, while there is a small number of households with high financial capital. Despite the relatively high level of average government subsidies in the central region, the financial advantages of the eastern region cannot be ignored. Regarding the social capital, 14.66% of the households have one or more family members working in the village committee. The average amount of cash gifts expended by each household is 3.12 thousand yuan, owing to the central region. The average social security is 4.26 thousand yuan, which provides more opportunities for a household to choose high-income livelihoods, especially in the eastern region. In terms of the rural human settlement conditions, the satisfaction levels for social security (3.48) and medical and health facilities (3.52) are the highest, followed by the satisfaction levels for service facilities (2.86) and social governance (2.84). In contrast, the satisfaction level for the rural employment services is the lowest (only 1.89). In terms of the regional comparison, the employment services and social security occupy a dominant position in the eastern region, accompanied by a relative lag in service facilities in the western region.

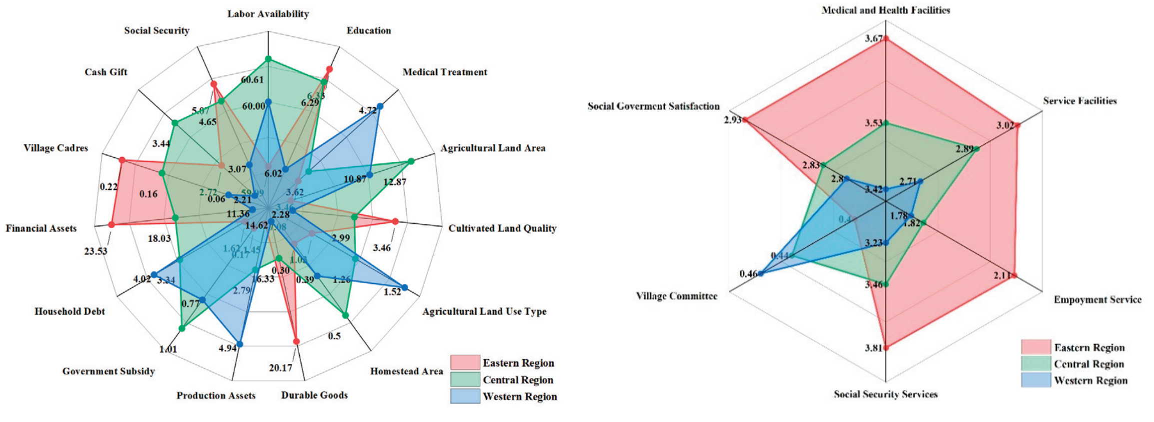
Table 4. Descriptive statistics for the explanatory variables.

Indictor			Unit	Mean	Std. Dev	Min	Max
Livelihood Capitals	Human Capital	Labor Availability	%	59.99	30.54	0.00	100.00
		Education	Years	6.23	2.79	0.00	16.00
		Medical Treatment	1000 Yuan	6.24	2.89	0.00	12.47
	Natural Capital	Agricultural Land Area	Mu	9.55	15.97	0.00	204.00
		Cultivated Land Quality	Index	2.89	1.44	0.00	5.00
		Agricultural Land Use Type	Counts	1.18	0.64	0.00	5.00
	Physical Capital	Homestead Area	Mu	0.50	0.66	0.01	8.00
		Durable Goods	1000 Yuan	17.13	27.96	0.00	205.00
		Production Assets	1000 Yuan	3.09	8.10	0.00	80.10
	Financial Capital	Government Subsidy	1000 Yuan	0.82	1.66	0.00	19.70
		Household Debt	1000 Yuan	4.09	18.45	0.00	240.00
		Financial Assets	1000 Yuan	17.11	38.25	0.00	364.05
	Social Capital	Village Cadres	Index	0.05	0.23	0.00	1.00
		Cash Gift	1000 Yuan	2.66	3.86	0.00	30.00
		Social Security	1000 Yuan	4.76	9.94	0.00	91.50
Rural Human Settlements	Infrastructure conditions	Medical and Health Facilities	Index	3.56	1.14	0.00	5.00
		Service Facilities	Index	2.87	1.80	0.00	5.00
	Public Service	Employment Service	Index	1.42	1.88	0.00	5.00
		Social Security Services	Index	3.73	1.03	0.00	5.00
	Social Governance	Village Committee	Index	0.06	0.23	0.00	1.00
		Social Governance Satisfaction	Index	2.84	1.27	0.00	5.00

Mu is an area unit used in rural China; 1 mu = 1/15 ha.

4.2. Analysis of Measurement Models

The results of the SEM model show the causal relationship between the observed variables and the latent variables (Figure 5). The confirmatory factor analysis proves that the model is acceptable (Appendix B).



(a) (b)

Figure 4. Descriptive statistics for the explanatory variables by region: (**a**) household livelihood; (**b**) rural settlement.

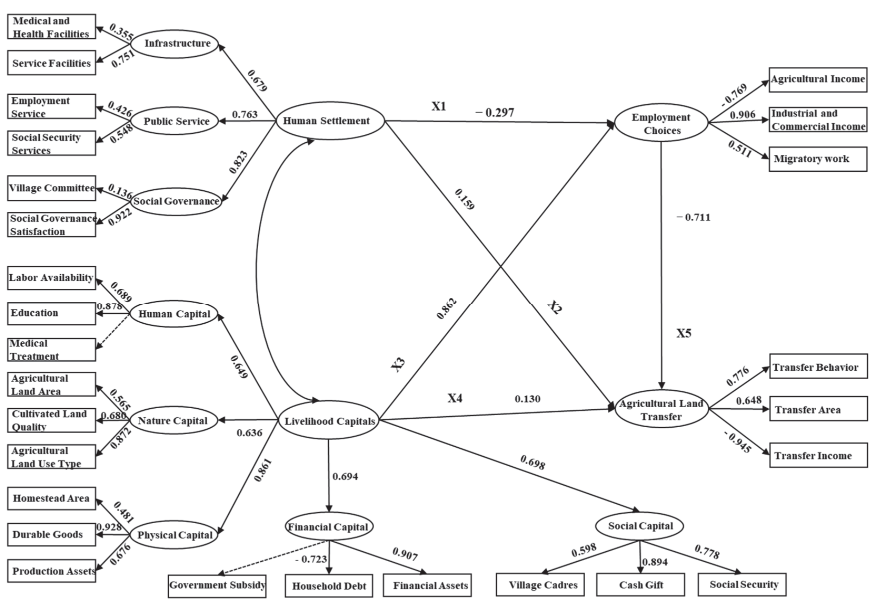


Figure 5. Parameter estimation results based on SEM.

4.2.1. Agricultural Land Transfer

The significant relationships show that the transfer behavior, transfer area, and transfer income can represent the agricultural land transfer well. Specifically, the transfer behavior has a significant positive effect on the agricultural land transfer, indicating that the behavior of the agricultural land inflow can improve the value of the agricultural land transfer. Since the transfer area equals the inflow area minus the outflow area, a high transfer area indicates a high inflow or a low outflow. As expected, there is a significant positive relationship between the transfer area and agricultural land transfer ($\beta = 0.648$, $p < 0.01$). Similarly, there is a significant negative correlation between the transfer income and agricultural land transfer ($\beta = -0.945$, $p < 0.01$). To sum up, the agricultural land transfer has a positive relationship with the agricultural land inflow.

4.2.2. Employment Choices

The results show that the three variables, namely the agriculture income, industrial and commercial income, and going out working, have statistically significant effects on the employment choices. The three variables have a consistent purpose, although they follow differently significant directions, which can be summarized as non-agricultural employment choices. Specifically, the relationship between the agricultural income and employment choices is negative and significant ($\beta = -0.769$, $p < 0.01$), while the relationship between the industrial and commercial income and migratory work is positive ($\beta = 0.906$, $p < 0.01$). Consequently, the values of the latent variables of rural employment choices will be greater if a household has lower agricultural income, higher industrial and commercial income, and a larger proportion of migrants.

4.2.3. Livelihood Capitals

There is a significant positive correlation between human capital and livelihood capital, which indicates that the households' livelihood capital increases with their human capital when other variables are controlled. For the human capital, the labor availability is a key variable ($\beta = 0.689$, $p < 0.01$), which determines the consumption and production of the household. The education level of the household members has significant associations with the human capital ($\beta = 0.878$, $p < 0.01$). Here, the relationship between the health status and human capital is not significant.

A statistically significant relationship can be found between the natural capital and livelihood capital ($\beta = 0.636$, $p < 0.01$). Households that possess larger quantities, better quality, and more types of agricultural land have higher stocks of natural capital. High quality usually means that more crop products can be produced. Additionally, the use of multiple crop cultivation approaches creates more opportunities to improve the livelihood capital, as market access largely determines crop selection.

The physical capital also has a significant positive relationship with household livelihood capitals ($\beta = 0.861$, $p < 0.01$). The homestead can play a positive role when the household livelihood capitals experience negative shocks. Durable goods allow households to find production channels or livelihood opportunities and make it easier to transport agricultural products. The ownership of production assets enhances the grain production capacity, thereby contributing to the management of larger or more agricultural land.

The financial capital is indispensable for the livelihood strategy of households, as proven by the statistically significant relationship between the financial capital and livelihood capital ($\beta = 0.694$, $p < 0.01$). The government subsidy is not significantly associated with the financial capital, perhaps because it merely meets the basic survival needs. Household debt has negative effects on the financial capital. Households with debts, especially poorer households, can severely impede their capacity to make economic and social choices regarding their precarious livelihoods.

The social capital has a positive relationship with the household livelihood capital ($\beta = 0.698$, $p < 0.01$). The significant relationship between the village cadres and social capital may reflect the fact that the cadres have a certain advantage over ordinary migrant rural workers when acquiring information ($\beta = 0.598$, $p < 0.01$). Households with greater social connectedness are more likely to learn about the opportunities for livelihood capital accumulation. Additionally, social security can enhance the social capital ($\beta = 0.778$, $p < 0.01$), thereby situating livelihood capitals under the broader umbrella of risk management.

4.2.4. Rural Human Settlements

The trend towards rural human settlements can be explained by their increased infrastructure, public services, and social governance, all of which show significant effects. Improvements in infrastructure can promote settlement conditions, as reflected by the positive values ($\beta = 0.679$, $p < 0.01$), explaining the changes in location of settlements from resource-based to facilities-based areas. Medical and health facilities are important driving factors to improve the rural human settlement conditions ($\beta = 0.355$, $p < 0.01$). Service facilities for the care of the elderly, children, and the disabled can support the sustainable development of rural human settlements for the protection of rural elderly individuals and children who have been left-behind. Their quality of life increasingly depends on public services, especially high-quality employment and social security services (β = 0.763, $p < 0.01$). Employment information and services are very important for rural residents, which could reduce the loss of the rural population and promote employment. The promotion of social security services is also an effective way to protect low-income households and alleviate social contradictions, which is conducive to improving the rural human settlement conditions. As an effective way to reflect the quality of social services, social governance is an important way of improving the settlement conditions (β = 0.823, $p < 0.01$). If a household can take the initiative to seek help from state bodies and achieve satisfactory solutions to production and life difficulty issues or conflicts, it can effectively improve its living stability to create safe and comfortable settlement conditions.

4.3. Causal Pathway of Agricultural Land Transfer Decisions

This paper hypothesizes that the influence of livelihood capitals and human settlements on agricultural land transfer can be divided into two pathways—the direct impact path and the indirect impact path, as mediated by employment choices. The SEM provides reliable evidence for the theoretical hypothesis (Table 5).

Table 5. Direct, indirect, and total effects of livelihood capitals and human settlements on agricultural land transfer.

Path	**β**	**SE**
Human Settlements->Agricultural Land Transfer	0.159	0.029
Human Settlements->Employment Choices->Agricultural Land Transfer	0.211	0.022
Human Settlements and Employment Choices->Agricultural Land Transfer	0.370	0.030
Livelihood capitals->Agricultural Land Transfer	0.130	0.051
Livelihood Capitals-> Employment Choices->Agricultural Land Transfer	−0.613	0.057
Livelihood Capitals and Employment Choices->Agricultural Land Transfer	−0.483	0.038
Human Settlements, Livelihood Capitals, and Employment Choices->Agricultural Land Transfer	−0.113	0.039

4.3.1. Impacts of Livelihood Capitals on Agricultural Land Transfer

The direct relationship between the livelihood capital and agricultural land transfer is primarily positive and significant (β = 0.130, $p < 0.01$). It shows that households with high livelihood capitals have a certain preference for land inflow. In terms of the indirect path, the livelihood of rural households has a significant negative impact on the path of agricultural land transfer through the mediating factor of rural employment choices (β = −0.613, $p < 0.01$), which indicates that the livelihood capitals tend to promote the outflow of the population from agriculture to obtain higher capital. Superior livelihood capitals not only support the inflow of agricultural land but also provide more opportunities for households to turn to industry and commerce or migration. The moderator–mediator test synthesizes the results of the direct and indirect paths, showing a significant negative impact on the whole (β = −0.483, $p < 0.01$). Compared with obtaining more agricultural income, households with superior livelihood resources are more likely to choose non-agricultural employment, which can lead to more funds and a better quality of life, thereby causing an overall trend of agricultural land outflow.

4.3.2. Impact of Rural Human Settlements on Agricultural Land Transfer

The direct effect of the rural human settlement conditions on agricultural land transfer is positive and significant (β = 0.159, $p < 0.01$). It also shows that a superior living environment is conducive to promoting the inflow of agricultural land to a certain extent.

As expected, the rural human settlement conditions exert a significant positive impact on agricultural land transfer through employment choices (β = 0.211, $p < 0.01$), indicating that a comfortable and convenient living environment can retain rural residents, thereby investing the labor force into agricultural land resources. The combined effect of the direct and indirect paths intensifies the positive impact of the rural human settlement conditions on agricultural land inflow (β = 0.370, $p < 0.01$), which proves the significant role of rural human settlement improvements in agricultural land use.

4.3.3. Impacts of Livelihood Capitals and Rural Human Settlements on Agricultural Land Transfer

The synthesis influence of livelihood capitals and rural human settlement conditions on agricultural land transfer is negative and significant (β = −0.113, $p < 0.01$). This result indicates that improving the living standards and settlement conditions is more conducive to agricultural production. The path to promote agricultural land inflow includes the direct impact of the livelihood capital, the indirect impact of the human settlements, and the direct and comprehensive impact of the human settlements. However, the indirect impact and comprehensive impact path of the livelihood capitals can promote the outflow of agricultural land. Hence, the results can provide insights for improving the agricultural land use efficiency and activating rural vitality.

4.4. Regional Differences in Path Coefficients

The multi-group SEM is used here to explore the consistency of the theoretical model among the different regional groups; that is, to test whether the causal path coefficients of the settlement conditions, livelihood capitals, and agricultural land transfer in the household clusters living in the eastern, central, and western regions are equal, as well as the mediating role of employment choices. It is necessary to evaluate the inter-group invariance of the measurement model and the equivalencies of the structural model. As shown in Appendix C and Table A5, there is no significant difference between groups in the measurement model, which means that the interpretation of the observed variable to potential variables spans the regional characteristics. It is worth noting that the path coefficients of the structural model (Figure 6) show significant differences among regions (Table A6).

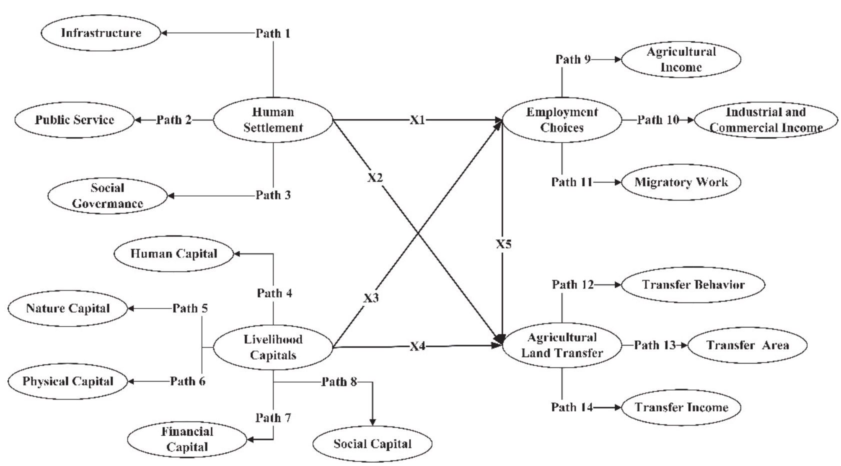


Figure 6. Structural models and paths.

To further locate the path, the critical ratio is employed. Its significance is used to prove the differences among regions of the same path, including the eastern region vs. central region, eastern region vs. western region, and central region vs. western region. As shown in Tables 6 and 7, the social governance in the western region plays a relatively weak role. The critical ratio and path coefficient of the natural capital in the three regions jointly express its prominent position in the central region, followed by the western region and the eastern region. The possible drivers are the abundant arable land resources in the central region and the dependence of the livelihood patterns on the natural resources in the western region. Relatively speaking, households living in the central region have obvious advantages in terms of their physical capital, possibly because they have more convenient conditions for mechanized farming and transportation. The advantages in terms of financial and social capital for households living in the eastern region is that they may profit from this economic development background, which has more employment opportunities and channels to promote capital accumulation. There are inverse differences in the roles of a migrant worker in the western region, indicating that the household tends to work locally even if it is far away from agriculture. Notably, the improvement in settlement conditions in the western region will promote such an exodus, and the accumulation of livelihood capitals will increase the incentives to stay away from agriculture. For households living in the eastern region, improved settlement conditions can increase the attractiveness of agricultural land.

Table 6. The structural model path coefficients for different regions.

No.	Path	Eastern Region	Central Region	Western Region
1	Settlements Conditions->Infrastructure	0.454	0.457	0.523
2	Settlements Conditions->Public Service	0.648	0.669	0.735
3	Settlements Conditions->Social Governance	0.728	0.768	0.661
4	Livelihood Capitals->Human Capital	0.420	0.464	0.461
5	Livelihood Capitals->Natural Capital	0.124	0.337	0.272
6	Livelihood Capitals->Physical Capital	0.724	0.802	0.771
7	Livelihood Capitals->Financial Capital	0.444	0.562	0.508
8	Livelihood Capitals->Social Capital	0.476	0.516	0.513
9	Employment Choices->Agricultural Income	−0.353	−0.364	−0.407
10	Employment Choices->Industrial and Commercial Income	0.476	0.487	0.512
11	Employment Choices-> Migratory Work	−0.033	−0.055	0.047
12	Agricultural Land Transfer->Transfer Behavior	0.832	0.826	0.813
13	Agricultural Land Transfer->Transfer Area	0.657	0.621	0.647
14	Agricultural Land Transfer->Transfer Income	−0.972	−0.957	−0.947
X1	Settlements Conditions->Employment Choices	−0.304	−0.302	0.240
X2	Settlements Conditions->Agricultural Land Transfer	0.227	0.203	0.139
X3	Livelihood Capitals->Employment Choices	0.712	0.822	0.848
X4	Livelihood Capitals->Agricultural Land Transfer	0.051	0.122	0.153
X5	Employment Choices->Agricultural Land Transfer	−0.795	−0.834	−0.853

From a comprehensive perspective, the settlement conditions can significantly promote agricultural land inflow in the eastern and central regions, either directly or indirectly through employment choices (Table A7). On the contrary, the livelihood capital can promote agricultural land outflow. In addition, the role of the settlement conditions and livelihood capitals in the eastern region in agricultural land transfer extends beyond the central region. When overlaying the livelihood capitals, the willingness to flow out of the agricultural land in the western region is even more obvious because the improved settlement conditions cannot keep households from devoting themselves to agriculture (Table 8).

Table 7. The critical path coefficient ratios of regional differences.

Path	Eastern vs. Central Region	Eastern vs. Western Region	Central vs. Western Region
1	0.748	0.753	0.022
2	0.293	0.823	0.229
3	0.757	−2.324 ***	−2.275 ***
4	−1.336	−1.137	0.601
5	2.101 ***	1.972 ***	2.079 ***
6	−1.987 ***	−1.183	3.655 ***
7	−2.149 ***	−1.964 ***	0.492
8	−1.962 ***	−2.562 ***	0.891
9	−0.032	−0.413	−0.406
10	0.762	0.637	1.402
11	−0.351	2.272 ***	2.691 ***
12	0.514	1.775	1.427
13	0.486	−1.898	−1.594
14	−0.079	1.068	1.292
X1	−0.672	5.189 ***	4.687 ***
X2	−3.604 ***	−3.718 ***	0.324
X3	−0.190	0.863	1.209
X4	1.356	−2.094 ***	−2.610 ***
X5	0.629	−0.794	−5.181

*** is $p < 0.001$.

Table 8. The direct, indirect, and total effects of livelihood capitals and rural human settlements on agricultural land transfer in different regions.

Path	Eastern Region	Central Region	Western Region
Settlements Conditions->Agricultural Land Transfer	0.227	0.203	0.139
Settlements Conditions->Employment Choices->Agricultural Land Transfer	0.242	0.252	−0.205
Settlements Conditions and Employment Choices->Agricultural Land Transfer	0.469	0.455	−0.066
Livelihood Capitals->Agricultural Land Transfer	0.051	0.122	0.153
Livelihood Capitals and Employment Choices->Agricultural Land Transfer	−0.566	−0.686	−0.723
Livelihood Capitals->Employment Choices->Agricultural Land Transfer	−0.515	−0.564	−0.570
Settlements Conditions, Livelihood Capitals, and Employment Choices->Agricultural Land Transfer	−0.046	−0.109	−0.636

5. Discussion

It is widely believed that agricultural land transfer or abandonment is an irrepressible socio-economic phenomenon, as non-agricultural income is more profitable than agricultural income [3,61]. However, earth-shaking changes have taken place in rural settlements with the improvement of infrastructure, acceleration of urban and rural transportation networks, and popularization of the Internet [26]. This paper assumes that the human settlement conditions and livelihood capitals can influence the decision-making regarding agricultural land transfer. Moreover, employment choice plays a mediating role in this process. Therefore, taking the human settlement conditions and livelihood capitals as independent variables, employment choice as mediating variable, and agricultural land transfer as the dependent variable, this paper uses the SEM to explore the causal pathways and their regional differences. It provides important insights for policy-makers to increase the value of agricultural land and enhance the rural vitality.

5.1. The Mediating Role of Employment Choices in the Process of the Agricultural Land Transfer

Rural residents will allocate their labor based on the comparative income provided by agricultural and non-agricultural industries. When this situation occurs, households choose to spend less time on farming, resulting in agricultural land transfer. With China's rapid economic development, it is controversial whether the increase in non-agricultural income will reduce or promote households' investment in agriculture. Most studies believe that the non-agricultural conversion of rural labor is the most fundamental driving force of agricultural land transfer [13,33]. However, some studies have pointed out that the agricultural land transfer lags far behind the non-agricultural transfer of the rural labor force [12]. The reason why many non-agricultural laborers did not give up agricultural management rights may be that migrant workers with rural hukou cannot enjoy the same rights and social security benefits as urban hukou under the urban–rural binary household registration system in China. In addition, migrant workers tend to retain their agricultural land management rights as a basic safety net due to their unstable jobs. There is no doubt that the allocation of the rural labor force will change the allocation of agricultural rural land resources. According to this paper, an increase in livelihood capital will enable households to access more employment opportunities, thereby promoting non-agricultural employment and leading to the outflow of agricultural land. When households living in rural areas have the same social welfare systems and living environments as the cities, they are more willing to stay in rural areas to accompany their family members. In this case, the households' dependence on agricultural land will increase. Therefore, the improvement of rural human settlements will promote the inflow of agricultural land by restraining the outflow of rural labor.

5.2. Interaction Effect of Rural Human Settlements and Livelihood Capitals on Agricultural Land Transfer

A rural settlement is a multi-dimensional integrated system formed by the interactions of various elements. Land elements play a fundamental role in providing resource support for rural revitalization and space for the development of rural industrial development. Agricultural land use is an important issue related to household livelihoods and agricultural development [62]. According to the agricultural household economic models, rural households, as the decision-makers for their agricultural land, take the maximization of family utility as the goal in the decision-making related to agricultural land production and management. The maximization of family utility is determined by the optimization of their production and quality of life [63]. Capital accumulation is the main goal in production optimization, and it is also the fundamental reason for agricultural land transfer. The integration of "resources, capital, and assets" would be a crucial way to promote rural development, improve the living environment, and provide a good business environment for agricultural industrialization. Some studies believe that households have more economic freedom and that their willingness to transfer agricultural land also increases with the increase in capital accumulation [12]. However, this study finds that the capital accumulation will promote the inflow of agricultural land because the capital can also be used as the cost of the land inflow in developing industries. Based on the processes of urbanization and economic development, the internal and external environmental conditions for rural and agricultural development are undergoing major changes in China. As an effective measure of change in agricultural production and household living environments, the rural human settlement transformation is highly valued by managers. It can be seen from the research results that the improvement in rural human settlement conditions will not only attract households to stay in rural areas and promote the inflow of agricultural land but will also directly strengthen the inflow of agricultural land, so as to allow the reallocation of agricultural land resources.

5.3. Regional Differences and Policy Recommendations

Based on the relationships between human settlements, livelihood capitals, employment choices, and agricultural land transfer explored in this study, the guidance, support, and restrictive policies offered by local governments play an important role in agricultural land use and rural revitalization. Facing the magnification of human settlement conditions and livelihood capitals in the central region and the unexpected role of the human settlement conditions in promoting the outflow of agricultural land in the western region, the formulation of policies such as the improvement of human settlements and land use should be carefully considered. In general, improving the efficiency of land use and protecting the agricultural land are the designated goals of such policies. More importantly, the actual needs of the farmers, who are the main actors in rural areas, and the direct beneficiaries should be considered in the policy design.

5.3.1. Attracting Talent to Return to Rural Areas

As the most important factor in rural development, rural–urban migration results in a series of socio-economic changes, including changes to the labor market, rural restructuring, and balanced regional development. The loss of the rural population, generally the most active, youngest, and highest quality sector of the labor force, has not only affected the age structure but has also changed the intellectual structure. The shortage of talent, less-educated human resources, and weakened main body of development caused by it have negative impacts on the development of modern agriculture and the popularization of agricultural science and technology. To alleviate these dilemmas, policy instruments that encourage and guide talent to return to the rural areas should be implemented. It is essential to specify supporting policies to attract and retain talent for long-term rural development. First, it is necessary to provide enterprise education and training on modern science and technology, modes of production, business philosophy, and practical technology for those return migrants, so as to cultivate them into new professional farmers to meet the development needs. Second, financial support is absolutely necessary. The government can give financial subsidies for innovation and entrepreneurship projects for return migrants, provide loans for agricultural moderate-scale operation, and implement a policy of tax and fee reductions.

5.3.2. Improving the Rural Human Settlements

With the development of the rural economy and the improvement of rural livelihoods, rural households are gradually giving up their traditional way of life and seeking a diversified lifestyle that covers employment, communication, leisure, entertainment, and tourism. In order to make better use of agricultural land and maintain the rural vitality, it is necessary to improve the rural human resettlement conditions in rural areas. Such conditions are an important source of rural residents' happiness and sense of achievement, which is a guarantee for better living standards and better quality of life for rural residents. Infrastructure, public services, and social governance are the main aspects of rural human settlements. First, the government should promote the extension of urban infrastructure construction to rural areas, including transportation, water conservancy, and energy projects, so as to promote the upgrading of rural infrastructure. To ensure the development of rural areas, the construction of digital rural facilities is urgent. More importantly, the gap between rural and urban areas in public education, health care, pension services, and social security should be gradually eliminated to ensure the equalization of basic public services between urban and rural areas. The promotion of cultural services based on folk art and group activities is an important way to enrich the spiritual and cultural lives of rural residents. In addition, there is still more room for the government to improve the social governance in rural areas, such as by increasing the ability of the grassroots cadres, emphasizing legal literacy, and improving the quality of life for rural residents.

5.3.3. Enhancing Household Livelihood Capitals

Ensuring the basic and long-term livelihoods has become the central issue in balancing urban–rural development and rural revitalization in China. Livelihood capitals play important roles in rural restructuring and household income growth, affecting the human non-agriculturalization, industrial cultivation, and land use transition processes and the rural self-development ability. The livelihood capitals of households, therefore, should be fundamentally promoted. The government should promote the transformation of the agricultural industrial structure, enhance the strength of the regional economic development, and improve the sustainability of the livelihood capital growth. Exploring the use of agricultural and rural resources and developing characteristic industries using new ideas, technologies, and channels are the predominant ways to improve the livelihood capitals, which should be encouraged and supported by the government. Land is the spatial carrier of rural industrial development. However, the rural areas are experiencing depopulation and housing modernization, which have led to the abandonment of agricultural land resources. Thus, the government should provide development spaces for modern agriculture and other rural industries, which would improve the household livelihood capital through consolidating the inefficiently utilized land, promoting land use circulation, and appropriate scale management.

6. Conclusions

From a macro-perspective, agricultural land transfer is an effective way to alleviate land abandonment and improve land use efficiency, and can contribute to food security and social stability. From a micro-perspective, agricultural land transfer can reduce the cost of agricultural production and change household livelihoods. Based on the dataset from the China Household Finance Studies (CHFS), this paper explored the impacts of livelihood capitals and rural human settlements on agricultural land transfer and regional differences using a structural equation model. The mediating role of employment choices was also examined.

The livelihood capitals were further divided into human, natural, physical, financial, and social capitals according to the sustainable livelihood framework. The results showed that the accumulation of livelihood capital can directly increase the possibility of agricultural land inflow, and can also indirectly reduce the dependence on agricultural land by stimulating non-agricultural employment. The rural human settlements were measured from three dimensions, including infrastructure, public services, and social security. The results indicated that the improvement of rural human settlement conditions can promote the inflow of agricultural land, but can also indirectly strengthen the willingness of households to flow into agricultural land by creating a comfortable living environment and restraining the outflow of the population. In the context of rural revitalization, the improvement of rural human settlements and household livelihood capitals can effectively promote agricultural land transfer, which could accelerate the transfer of agricultural land from non-agricultural households to those with farming willingness, except for in the western region. Therefore, it is necessary to fully grasp the internal mechanism involved when making policies. There is also a practical need to attract talent to return to the rural areas and provide them with training and financial support to develop modern agriculture, so as to promote the transformation of agricultural land use from traditional extensive agriculture to intensive modern agriculture.

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

Appendix A

Table A1. Scope of the explanatory variable.

No	Indictor	Scope
1	Agricultural production and operation	Cultivate food crops; Cultivate economic crops; Plant and transport trees; Raise livestock and poultry; Breed and fish aquaculture; Cultivate other crops
2	Industrial and commercial production	Self-employed/industrial and commercial enterprises; Joint-stock limited company; Limited liability company; Partnership; Sole proprietorship; No formal form of organization; Others
3	Satisfaction	1 = very dissatisfied; 2 = not very satisfied; 3 = average; 4 = fairly satisfied; 5 = very satisfied
4	Help degree	1 = none; 2 = not too large; 3 = average; 4 = relatively large; 5 = very large
5	Cultivated land quality	1 = very poor; 2 = poor; 3 = average; 4 = good; 5 = very good
6	Agricultural land use type	Cultivated land; woodland; grassland; garden; others
7	Durable Goods	Car; camera/camera; TV; Washing machine; Refrigerator; Air conditioner; Computer; Audio; Water heater; Furniture; Musical instrument; Mobile phone; Induction cooker; Microwave oven; Water dispenser; Others
8	Government subsidy	Special poverty allowance; Only child award; Five guarantees allowance; Pension; Relief/disaster relief fund; Food subsidy; Grain for green; Subsistence allowance; Education subsidy; Housing subsidy; Agricultural subsidy; Others
9	Household Debt	Education debt; Medical debt; Credit card; Others
10	Financial Assets	Current deposits; Fixed deposits; Stocks; Funds; Financial products; Bonds; Derivatives; Non-RMB assets; Precious metals; Cash; Others
11	Cash Gift	Holiday expenses; Red and white happy expenses; Others
12	Social Security	Social endowment insurance and enterprise annuity; Medical insurance; Unemployment insurance; Housing accumulation fund; Industrial and commercial insurance; Maternity insurance; Others

Appendix B

A confirmatory factor analysis (CFA) is employed to confirm whether the data compiled here have a good fit for the model estimation by measuring the convergent validity, discriminant validity, and construct validity. Specifically, the convergent validity evaluates whether the observable variables can fully explain each latent variable and analyze the internal consistency of the variables. The average variance extracted (AVE, greater than 0.5) and the composite reliability (CR, greater than 0.7) are commonly used to determine the degree of convergent validity [64]. The discriminant validity is measured via the factor correlations of the latent variable, which reflect the independence of the different latent variables. The discriminant validity is satisfactory if its value exceeds the square root of the AVE (Table A2). The construct validity of the model can be evaluated via model fit indices (Table A3) [65]. In addition, to test the significance of the impacts of rural human settlements and livelihood capitals on agricultural land transfer as mediated by employment choices, in this paper we conduct a moderator–mediator test with a 95% confidence interval (Table A4) [66,67]. The path is significant when there is no zero between the lower and upper limit of the bias-corrected 95% CI and percentile 95% CI [67].

Table A2. Confirmatory factor analysis (CFA) of the discriminant validity.

	AVE	CR	Human Capital	Natural Capital	Physical Capital	Financial Capital	Social Capital	Infrastructure	Public Service	Social Governance
Human capital	0.501	0.741	0.708							
Natural capital	0.514	0.755	0.011 ***	0.717						
Physical capital	0.517	0.750	0.127 ***	0.057 ***	0.719					
Financial capital	0.533	0.764	−0.027 ***	−0.007 ***	−0.109 ***	0.730				
Social capital	0.587	0.806	0.044 ***	0.028 ***	0.147 ***	−0.028 ***	0.766			
Infrastructure	0.621	0.761	0.034 ***	0.018 ***	0.058 ***	0.038 ***	0.038 ***	0.788		
Public service	0.592	0.742	0.048 ***	0.025 ***	0.081 ***	0.052 ***	0.053 ***	0.280 ***	0.769	
Social governance	0.577	0.722	0.052 ***	0.027 ***	0.088 ***	0.057 ***	0.058 ***	0.336 ***	0.396 ***	0.760
The square root of AVE			0.708	0.717	0.719	0.730	0.766	0.788	0.769	0.760

The square root of the AVE is shown in bold on diagonals. Off the diagonals are Pearson correlations of constructs. The discriminant validity is achieved when the diagonal value in bold is higher than the values in its row and column. *** is $p < 0.001$.

Table A3. Confirmatory factor analysis (CFA) of the discriminant validity.

GOF Measures	χ2/df	CFI	GFI	AGFI	NFI	IFI	RMSEA
Recommended levels	<5.000	>0.900	>0.900	>0.900	>0.900	>0.900	<0.050
Test value	4.894	0.945	0.976	0.965	0.932	0.945	0.044
Result	Pass	Pass	Pass	Pass	Pass	Pass	Pass

CFI is the comparative fit index; GFI is the goodness-of-fit index; AGFI is the adjusted goodness-of-fit index; NFI is the normed fit index; IFI is the incremental fit index; RMSEA is the root mean square error of approximation.

Table A4. Confirmatory factor analysis (CFA) of the discriminant validity.

Path	Bias-Corrected 95% CI		Percentile 95% CI	
	Lower	Upper	Lower	Upper
Settlements Conditions->Agricultural Land Transfer	0.102	0.213	0.105	0.217
Settlements Conditions->Employment Choices->Agricultural Land Transfer	0.197	0.227	0.196	0.226
Settlements Conditions and Employment Choices->Agricultural Land Transfer	0.004	0.106	0.001	0.104
Livelihood Capitals->Agricultural Land Transfer	0.134	0.627	0.135	0.631
Livelihood Capitals and Employment Choices->Agricultural Land Transfer	−0.467	−0.036	−0.467	−0.036
Livelihood Capitals->Employment Choices->Agricultural Land Transfer	−0.322	−0.275	−0.313	−0.259
Settlements Conditions, Livelihood Capitals, and Employment Choices->Agricultural Land Transfer	−0.229	−0.103	−0.238	−0.111

Appendix C

Table A5. Direct, indirect, and total effects of livelihood capitals and human settlements on agricultural land transfer.

Model	ΔCMIN	ΔDF	*p*
Measurement weights	5.181	6	0.520817106
Structural covariances	18.799	16	0.279224094
Measurement residuals	38.882	26	0.050034415

Table A6. Direct, indirect, and total effects of livelihood capitals and human settlements on agricultural land transfer.

Model	ΔCMIN	ΔDF	p
Measurement weights	67.094	20	5.391×10^{-7}
Structural weights	127.887	30	4.736×10^{-14}
Structural covariate	134.267	36	2.987×10^{-13}
Structural residuals	134.267	36	2.987×10^{-13}
Measurement residuals	498.861	64	1.323×10^{-68}
Measurement weights	67.094	20	5.391×10^{-7}

Table A7. Standardized bootstrap moderator–mediator test of the indifference region.

Path	Eastern Region				Central Region				Western Region			
	Bias-Corrected 95% CI		Percentile 95% CI		Bias-Corrected 95% CI		Percentile 95% CI		Bias-Corrected 95% CI		Percentile 95% CI	
	Lower	Upper	Lower	Upper	Lower	Upper	Lower	Upper	Lower	Upper	Lower	Upper
Settlements Conditions->Agricultural Land Transfer	0.022	0.264	0.038	0.259	0.083	0.14	0.076	0.152	0.008	0.211	0.007	0.228
Settlements Conditions->Employment Choices->Agricultural Land Transfer	0.107	0.124	0.112	0.119	0.025	0.195	0.027	0.166	−0.119	−0.067	−0.097	−0.089
Settlements Conditions and Employment Choices->Agricultural Land Transfer	0.041	0.209	0.032	0.200	0.024	0.107	0.027	0.105	−0.195	−0.032	−0.195	−0.031
Livelihood Capitals->Agricultural Land Transfer	0.270	0. 566	0.233	0. 505	0.097	0. 381	0.102	0. 395	0.480	0.760	0. 451	0.744
Livelihood Capitals and Employment Choices->Agricultural Land Transfer	−0.597	−0.329	−0.534	−0. 303	−0.634	−0.381	−0.626	−0.375	−0.755	−0.500	−0.711	−0.485
Livelihood Capitals->Employment Choices->Agricultural Land Transfer	−0.142	−0.022	−0.141	−0.028	−0.337	−0.203	−0.321	−0.187	−0.099	−0.075	−0.083	−0.074
Settlements Conditions, Livelihood Capitals, and Employment Choices->Agricultural Land Transfer	−0.264	−0.077	−0.263	−0.075	−0.320	−0.135	−0.314	−0.132	−0.204	−0.012	−0.209	−0.016

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How Do Network Embeddedness and Environmental Awareness Affect Farmers' Participation in Improving Rural Human Settlements?

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Abstract: Based on social embeddedness theory, this paper aims to explore the influence mechanism of network embeddedness and environmental awareness on farmers' participation in improving rural human settlements (IRHS). This research applies the Logit model and the Bootstrap method, using survey data from 495 farmers in Hubei Province, China. The results show that: (1) relational embeddedness has a significant negative impact on the centralized treatment of farmers' domestic sewage, implying that strengthening the relationship between farmers and households helps to provide them with centralized treatment for domestic sewage; (2) environmental awareness has a significant positive impact on the centralized treatment of farmers' domestic sewage, implying that the enhancement of farmers' environmental awareness increases the promotion centralized treatment for domestic sewage; and (3) structural embeddedness can further affects farmers' environmental awareness and then affects their participation in the centralized treatment of domestic sewage, implying that environmental awareness has a mediating effect between structural embeddedness and the centralized treatment of farmers' domestic sewage. Overall, it is necessary not only to encourage the establishment of extension and discussion networks for farmers (relational embeddedness) to participate in IRHS but also to improve environmental education for farmers, especially by increasing their access to environmental knowledge and information (environmental awareness in mountainous areas, and, finally to support farmers. The relationship between the members and the village cadres (structural embeddedness) can further improve farmers' awareness of participation in IRHS to better guide them in the centralized treatment of domestic waste and domestic sewage.

Keywords: network embeddedness; environmental awareness; improving rural human settlements (IRHS); farmers' participation behavior

1. Introduction

Currently, China is experiencing unprecedented rapid urbanization, but many major issues prevail in rural development, leading the government to vigorously promote rural revitalization. With rapid population growth and economic and urban development, domestic waste management has become a pervasive global pressure [1]. Developing countries also experience rural domestic waste management as a serious challenge [2], while there is no distinction between domestic waste management in urban and rural areas in developed countries [3]. Although China's agricultural economy continues to grow and farmers' incomes continue to rise, littering and the indiscriminate discharge of sewage are still a common picture in many rural areas. In the past 40 years, with the rapid development of the rural economy and the change of lifestyle, the quantity and variety of rural household garbage have increased rapidly. In 2017, China's total domestic waste reached 213 million tons and is expected to grow by up to 300 million tons in 2020 [4]. According to the statistical data from the Development Prospects and Investment Forecast Analysis Report of China's Rural Waste Treatment Industry from 2018 to 2023, the output of rural household garbage in China was about 180 million tons in 2017, with a per capita daily output of 0.8 kg. Currently, there are at least 70 million tons of domestic waste that have not been treated [5]. In many villages, domestic waste is piled up in a disorganized way, burned in the open air, surrounded by garbage, and blocked by garbage, which not only breeds germs and spreads disease but also pollutes the land, groundwater, and surface water [6]. Rural domestic waste has become one of the main pollution sources in the rural environment. Large amounts of household garbage exacerbate environmental harm by posing an imminent threat to safety. While the main waste disposal measures are still mixed landfill (53.0%) and mixed incineration (43.8%) [7], the promotion of waste classification and the reduction in the waste volume are fundamental to solving the waste problem, as these actions can reduce environmental pollution, save land, promote the recycling of resources, and improve public value.

At present, some untreated domestic waste and sewage are directly discharged into rivers, lakes, and other surface water bodies in certain underdeveloped rural areas in China, which considerably affects the living environment and the water bodies [8]. Due to their high operational management requirements, high costs, and water quality standards [9], there are some challenges to using integrated treatment processes in these relatively dispersed areas (such as townships). The results of the implementation of numerous rural governance measures in the countryside have attracted increasing attention from policymakers. The implementation effect of these initiatives mainly depends on whether and to what extent local farmers are actively encouraged to participate in improving rural human settlements (IRHS) [10]. Rural households are the direct beneficiaries of and important participants in IRHS [11], and their attitude toward IRHS is crucial to the policy formulation and financing of IRHS [10]. Therefore, research on farmers' participation in IRHS and its influencing mechanism is urgently needed. Furthermore, this study discusses its formation mechanism from the perspective of social embeddedness theory. Therefore, improving rural human settlements is one of the important tasks within the rural revitalization strategy.

Recently, with the great improvement of material living standards, rural residents' demand for a better environment has increasingly grown. The availability of public goods and local infrastructure and the effective governance of rural cooperatives are related to the success or failure of the construction of a beautiful village. Many sociologists assume that environmental issues are ultimately caused by irrational individual environmental behaviors [12]. This understanding of ecological and environmental problems emphasizes the role of individuals in coping with the current ecological crisis. Consequently, there is a growing public concern about environmental sustainability issues and the impact of human behavior on natural ecosystems [13,14], which also elevates participation in IRHS to a high priority in public debate [15].

The concept of rural human settlements is derived from the concept of human settlement environments, and rural human settlements are a kind of non-material organism that is related to agricultural production and farmer reproduction [16]. According to Wu's definition, rural human settlements include the natural system, human system, residential system, social system, and support system; IRHS is the main area of focus through which the support system can improve important aspects of farmers' living standards, including rural garbage control, toilet waste control, domestic sewage control, upgrades in the appearance of villages, village planning, village management, etc. [17]. IRHS relates to the supply of public goods and is also concerned with the characteristics of private goods because the government attends to IRHS while the farmers contribute to the improvement of the environment around their houses. Farmers' participation in IRHS is guided by the government to promote the appearance of villages and, taking the periphery of rural households as the model, to attend to the centralized treatment of domestic waste and domestic sewage, human and animal waste treatment, environmental greening, debris management, and other activities [10,18]. Although IRHS covers a range of features, depending on the rural reality, this study mainly focuses on two aspects: the centralized treatment of domestic waste and domestic sewage.

IRHS can mitigate environmental damage through direct and indirect means and improve the environment individually or collectively [19]. It is influenced by internal and external factors [20–22]. Without knowledge of the environment, consciously caring about it or adopting an environmentally conscious attitude is not possible [23]. Varela-Candamio et al. [24] argue that governments should ascribe importance to public environmental education, improve public environmental knowledge, and promote more environmentally friendly behavior. According to Hungerford and Volk [25], environmental education is different from other forms of general education because consciousness does not necessarily promote behavior. However, Frick et al. [26] and Bartiaux [27] found no correlation between environmental knowledge and behavior. Recently, the issues of solid waste discharge [28–30], domestic sewage discharge [31–35], and rural household toilet reform [36–38] have received much attention. Farmers' participation in agroecological production [39–42], agricultural land rehabilitation [43,44], and environmental management [45–48] has been discussed, and it provides a useful reference for this paper.

China's rural community is a typical "acquaintances society", with the characteristics of differential patterns, in which the behavior of rural households is not only the result of rational individual decision-making but also of conformity with group decision-making [49–51]. Individuals can influence those around them to participate in environmental protection through learning, interaction, and reciprocity within their relationship networks [52]. These rural social networks perform multiple functions, such as the spread of information and social learning, which can effectively promote farmers' participation in IRHS [53–55]. Another key factor affecting farmers' participation in IRHS is environmental awareness. The level of environmental awareness directly affects whether farmers contribute to IRHS and is also influenced by social networks because communication between farmers can effectively improve their environmental awareness.

Through our literature review, we found that, although the existing research in different dimensions discusses farmers' participation in IRHS, further expansion in the following three aspects remains to be addressed. Firstly, few studies analyze the environmental impact mechanism of farmers' IRHS and did not reveal the influence of regional differences. Secondly, although some scholars have discussed the influence of farmers' participation in IRHS from the perspective of social networks or environmental awareness, most have not incorporated these three aspects into one research framework. Few studies have considered the possible mediating role of environmental awareness between them. Furthermore, the mechanism through which network embeddedness affects farmers' participation in IRHS through their environmental awareness is still unclear. Thirdly, most existing studies use Logit or Probit models for analysis, which are not conducive to identifying the critical path affecting farmers' participation in IRHS, nor the direct and indirect effects of various factors. Thus, to propose a research framework and to further study the mechanism behind farmers' participation in IRHS from the perspective of social networks and environmental awareness, and then to better guide and promote their participation in IRHS, this study used questionnaire survey data from farmers in some counties and cities in central China to construct an analytical framework of the impact mechanism of network embeddedness and environmental awareness on farmers' participation in IRHS. By using the Logit model and Bootstrap method to explore its mechanism, and by guiding farmers to actively participate in IRHS more effectively, it will be possible to carry out comprehensive and well-organized land management and ecological restoration in the future. This study focused on assessing how network embeddedness and environmental awareness shape farmers' participation in IRHS and formulated the following research questions (RQs).

RQ1: What are the challenges faced by typical villages in improving rural human settlements during the operational stage?

RQ2: What is the scope of application of different governance models for improving rural human settlements in typical villages?

The results of this research could inform strategies to reduce environmental damage through interventions (e.g., fostering environmental attitudes and emotions) influence individual participation in IRHS.

The remainder of this paper is organized as follows. The second part constitutes the theoretical analysis and research hypotheses. Section 3 presents the data sources and research methods, including the population and sample studies, measurement, and analysis strategies. The Section 4 introduces the results of this empirical study, including the model fitting test, structural results, mediating effect analysis, and multi-group analysis. Section 5 discusses the findings. Finally, the conclusion and problems for further research are presented.

2. Theoretical Analysis

Although the improvement of rural human settlement environments has been put on the agenda and achieved some positive results, the overall progress level is still not high, and there are widespread problems of imbalance and insufficiency [10]. Until 2017, the domestic garbage treatment rate in rural areas of China reached 72.99%, of which the domestic waste treatment rate was only 23.62% and the rural domestic sewage treatment rate was 17.19% [10]. To fundamentally improve the rural human environment, the Chinese government has put forward the rural human environment improvement action plan and issued a series of documents, including the rural revitalization strategy [56] and the three-year action plan for rural human environment improvement [57]. In January 2019, the Central Agricultural Office, the Ministry of Agriculture and Rural Affairs, and other 18 departments jointly developed the "rural habitat environment improvement village cleaning action program". This program calls for mobilizing farmers to participate in rural environmental remediation and focus on solving rural environmental problems [58]. These improvements in the rural human environment can provide farmers with a clean and tidy village environment, complete infrastructure, and sound public services [11,59]. These can effectively improve farmers' well-being and promote the construction of rural ecological civilization [60].

Based on social embeddedness theory and combined with current research on the effect of network embeddedness [52,61] and environmental awareness [23] on farmers' participation in IRHS, this study constructs the following research framework: network embeddedness, environmental awareness, farmer participation in IRHS" (Figure 1). Social embeddedness theory divides network embeddedness into two types: relational embeddedness and structural embeddedness [62–64]. Specifically, relational embeddedness refers to the relational network formed by embedding rural households' behaviors in the surrounding villagers [65]. Structural embeddedness refers to the network structure embedded in rural households and their position in the network [66]. Environmental awareness refers to farmers' basic awareness of the ecological environment and their understanding and grasp of relevant knowledge based on ecosystem services, which is the basis for farmers to construct ecological values [67]. Referring to an existing study [28], farmers' participation in IRHS was represented in this paper by their participation in the treatment of domestic waste and sewage. Therefore, the main research topics were as follows: (1) the direct effect of network embeddedness on farmers' participation in IRHS; (2) the direct influence of environmental awareness on farmers' participation in IRHS; (3) analysis of the mediating effect of environmental awareness between network embeddedness and farmers' participation in IRHS.

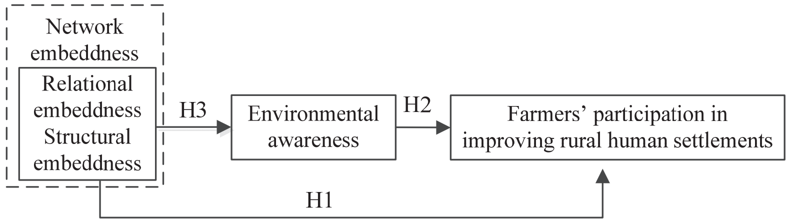

Figure 1. The mechanism influencing network embeddedness and environmental awareness on farmers' participation in IRHS.

2.1. Direct Impact of Network Embeddedness on Farmers' Participation in IRHS

Network embeddedness originates from Polanyi's idea of "the social embedding of the economy" [68], while Granovetter extended the social embeddedness theory and developed an important argument in favor of "the embedding of economic behavior in social structure" [62], which argues that human economic activities are conducted based on a certain network of relationships and have been embedded in the network structure. The economic behaviors of rural households are usually to a certain extent, restricted by the structure of the social relations in which they are located. They are not only independent but also "embedded" in a certain network of relations. While network embeddedness is mainly composed of relational embeddedness and structural embeddedness [62–64], relational embeddedness mainly includes relationship strength and relationship quality [65], and structural embeddedness mainly includes network size, network density, and network location [66]. The quality and strength of relationships between farmers have a direct impact on the knowledge that farmers can acquire. Although explicit knowledge can be obtained through observation or imitation, tacit knowledge can only be obtained through higher-quality relationships [64,69]. Good interpersonal relationships and emotional closeness among relatives and friends can help farmers to share tacit knowledge. This further strengthens trust and cohesion among farmers, promotes the establishment of a mutually beneficial cooperation mechanism among farmers [52], and further improves farmers' participation in IRHS. Therefore, this paper proposes the following research hypothesis:

Hypothesis 1a. *Relational embeddedness has a positive impact on farmers' participation in IRHS.*

In addition, the social network in which farmers are embedded is conducive to information sharing and communication among farmers, and the formation of a villager relationship network assists in promoting farmers to engage in more in-depth, extensive, and effective information exchange [66]. Farmers' participation in IRHS is easily affected by the behaviors of surrounding farmers, especially those who play an important role in the network of villagers [70]. The complex network formed among farmers can provide them with more important information, promote the dissemination and sharing of knowledge related to rural ecological environment governance, and guide them to participate in IRHS in practice. Therefore, this paper proposes the following research hypothesis:

Hypothesis 1b. *Structural embeddedness has a positive impact on farmers' participation in IRHS.*

2.2. Direct Impact of Environmental Awareness on Farmers' Participation in IRHS

Environmental awareness is a subjective feeling and awareness of environmental conditions and environment-related issues and refers to the way individuals think about environmental issues and related political actions [67]. The relationship between environmental awareness and environmental protection behavior has been widely discussed in academic circles. According to some studies, no significant correlation exists between environmental awareness and individual pro-environmental behavior [71], which might be attributed to individual environmental awareness not being related to actual pollution. Environmental pollution may not be sufficient to stimulate individual environmental protection behavior [72]. However, most scholars believe that the more knowledge individuals possess about the potential risks and threats that may arise from environmental problems, the more attention they pay to the solution of environmental problems and the improvement of environmental quality, and the more likely they are to adopt more responsible and positive environmental protection behaviors [73–77]. In other words, individual environmental awareness may have a certain influence on a person's environmental behavior [23]. Furthermore, individual environmental awareness first affects their environmental attitude, then affects their sense of responsibility, and finally affects their environmental behavior [73]. Similarly, the deeper farmers' understanding of the rural ecological environment, the higher their awareness, and the more likely they are to participate in the governance of rural human settlements [78]. Therefore, this paper proposes the following research hypothesis:

Hypothesis 2. *Environmental awareness has a positive impact on farmers' participation in IRHS.*

2.3. Mediating Effect Analysis of Environmental Awareness

The different areas in which individuals live and the different elements in their social networks lead to differences in individual awareness of the environment. Network embeddedness has many functions (e.g., risk avoidance, information sharing) that affect individual environmental awareness. Similarly, the long-term formation of a variety of relationship networks among farmers is conducive to promoting information exchange and sharing, which can effectively reduce information asymmetry [61]. Through the efficient dissemination of environment-related knowledge and information, farmers' environmental awareness can be improved and their sense of responsibility enhanced, which will finally assist them in consciously participating in environmental activities (e.g., IRHS) [73,75,79,80]. In addition, the deeper farmers' understanding of IRHS, the more likely they are to contribute to IRHS [81]. In other words, network embeddedness first promotes farmers' environmental awareness and then affects their participation in IRHS. Therefore, this paper proposes the following research hypotheses H3a and H3b:

Hypothesis 3a. *Environmental awareness has a mediating effect on the influence of relational embeddedness on farmers' participation in IRHS.*

Hypothesis 3b. *Environmental awareness has a mediating effect on the influence of structural embeddedness on farmers' participation in IRHS.*

3. Research Area and Data Overview

The data used in this paper originate from the questionnaire survey conducted by the College of Public Administration of Huazhong Agricultural University in Wuhan City, Huangshi City, Jingmen City, and Tianmen City of Hubei Province in November 2019. To ensure data quality, the research team participated in detailed survey training and guidance for researchers. Based on the research plan, the survey process included the following elements. The poll was conducted according to the stratified random sampling method to extract Wuhan City, Huangshi City, Jingmen City, and Tianmen City as the study area. Further classification identified the Huangpi district in Wuhan City, Daye county-level city in Huangshi City, Jingshan county-level city, Zhongxiang county-level city in Jingmen City, and Tianmen City as samples areas. Three streets, five towns, and one township were randomly selected from these five sample areas. Next, according to the level of economic development of each town (or street, or township), three or four administrative villages were randomly selected in each sample town (or street, or township); the selected villages are all typical villages. Finally, 20–30 rural households were randomly selected in each sample administrative village as the survey subjects, and face-to-face interviews were conducted in households or the field. Most of the respondents to the survey were heads of rural households or family decision-makers.

A total of 520 questionnaires were distributed in this survey, and 495 valid survey responses were obtained with an effective rate of 95.19%. Specifically, 89, 112, 215, and 79 valid questionnaires were collected in Wuhan City, Huangshi City, Jingmen City, and Tianmen City, respectively. The questionnaire mainly included the individual characteristics, family characteristics, social network, environmental awareness, and the interviewees' level of participation in IRHS. All the collected sample questionnaires were checked and reviewed by the research group and then collected to establish a sample database.

4. Analysis Method and Variable Setting

4.1. Analysis Method

Combined with the above theoretical analysis and existing research [23,52,67,81], and because the explained variables were dummy variables, this paper adopted the Logit model for empirical analysis with the following preliminarily equation:

$$Y = \beta_0 + \beta_1 NE + \beta_2 EC + \beta_3 Control + \varepsilon \tag{1}$$

Equation (1), Y is the explained variable, namely, the farmers' participation in IRHS. NE and EC denote network embeddedness and environmental awareness, respectively. Additionally, based on existing research and considering data availability, the control variables are included in equation (1) as $Control$. β_0 is a constant term, β_1, β_2, and β_3 are the corresponding regression coefficients of the above explanatory variables, and ε is a random disturbance term.

4.2. Variable Settings

According to the actual situation in the study area and existing research results [3,55], the corresponding variables were selected (Table 1). Specifically, the explained variable was whether farmers participated in IRHS, including "whether they participate in the centralized treatment of domestic waste" [3] and "whether they participate in the centralized treatment of domestic sewage" [55]. The core explanatory variables included network embeddedness and environmental awareness. Network embeddedness included relational embeddedness and structural embeddedness [64]. Relational embeddedness consisted of relationship strength and relationship quality [65]. Structural embeddedness consisted of network size, network density, and network location [66]. The control variables mainly included individual characteristics [9], household characteristics [82,83], village characteristics [84], regional social and economic characteristics [85], and other indicators. Additionally, the results of the collinearity test showed the absence of any significant multicollinearity among the variables [86,87], which met the requirements of econometric analysis.

Table 1. Variable values of surveyed households.

Variable	Variable Meaning and Assignment	Mean Value	Standard Deviation
Explained variable			
Whether to participate in the centralized treatment of domestic waste (Y_1)	Yes = 1, no = 0. Farmers dumping waste in open spaces, roadsides, ditches, and rivers were considered as not participating in the centralized treatment of domestic waste, no = 0; when farmers threw living garbage into the cesspit, into the trash can (pool), or carried out the centralized classification of household garbage when removing this kind of garbage, or if the garbage was subjected to decomposition, such actions were regarded as participating in the centralized treatment of domestic waste, yes = 1.	0.91	0.29
Whether to participate in the centralized treatment of domestic sewage (Y_2)	Yes = 1, no = 0. Farmers passing the sewage through the drain into rivers, roadsides, ditches, yards, etc., or pouring it into the field via an infiltration pool were all regarded as not participating in the centralized treatment of domestic sewage, no = 0; farmers collecting and discharging domestic sewage through ta sewer, or collecting domestic sewage through the sewer and then purifying it, were regarded as the centralized treatment of domestic sewage, yes = 1.	0.66	0.47
Core explanatory variable Network embeddedness Relational embeddedness			
Relationship intensity	Do you often lend property (e.g., farm tools, machinery) to friends or neighbors? Yes = 1, no = 0	0.74	0.44
Relationship quality	Do you trust your house to your neighbor when you go out? Yes = 1, no = 0	0.79	0.41
Structural embeddedness			
Network size	Do you know many people in your local area? Very few = 1, few = 2, usual = 3, many = 4, very many = 5	3.43	0.85
Network density	Your contact with relatives and family members. No contact = 1, occasional contact = 2, general = 3, more contact = 4, frequent contact = 5	3.72	0.80
	Your contact with non-relatives of villagers and village cadres. No contact = 1, occasional contact = 2, general = 3, more contact = 4, frequent contact = 5	3.08	2.02
Network location	How well you are respected by the local villagers. Very respectful = 1, somewhat respectful = 2, general = 3, somewhat disrespectful = 4, very disrespectful = 5	2.55	0.63
Environment awareness	Do you care about the quality of the surrounding environment? Very unconcerned = 1, relatively unconcerned = 2, general = 3, relatively concerned = 4, very concerned = 5	3.87	1.51
	What do you think of the surrounding ecological environment? Very poor = 1, relatively poor = 2, average = 3, fairly good = 4, very good = 5	3.67	0.83

Table 1. *Cont.*

Variable	Variable Meaning and Assignment	Mean Value	Standard Deviation
Control variables			
Gender of the household head	Male = 1, female = 0	0.94	0.24
Age of the household head	Under 35 = 1, 35-45 = 2, 45-55 = 3, 55-65 = 4, 65+ = 5	3.92	0.95
Education level of the household head	Illiteracy = 1, primary school = 2, junior high school = 3, high school or technical secondary school = 4, junior college and above = 5	2.54	0.90
Whether village cadres (leader) are in the family	Yes = 1, no = 0	0.07	0.26
Whether family members are party members	Yes = 1, no = 0	0.08	0.26
Contracted land area	The area is subject to the confirmation and certification of the second land contract management right (unit: mu)	11.92	22.83
Family size	The total population of rural households	3.05	1.09
Annual household income level	Total annual income of each labor force in rural households, unit: yuan. Less than 25,000 = 1, 25,000-50,000 = 2, 50,000-75,000 = 3, 75,000-100,000 = 4, more than 100,000 = 5	3.15	1.73
The proportion of agricultural income	The proportion of agricultural income in the total income of rural households	0.21	0.33
Regional social and economic development level	According to each county area (city), the economic development level is divided. High = 1, low = 0	0.59	0.49
Whether to carry out industrial integration	Whether the village has carried out industrial integration and the development of related industries and projects, yes = 1, no = 0	0.31	0.46

5. Empirical Analysis

5.1. Descriptive Analysis

The statistical results of the farmers' participation in IRHS are shown in Table 2.[1] Regarding the farmers' participation in the centralized treatment of domestic waste, in general, 450 households treated their garbage, accounting for 90.91% of the total sample. A total of 328 households, accounting for 66.26% of the total sample, participated in the centralized treatment of domestic sewage. To some extent, the high participation rate shows that Hubei Province, as a pilot province of overall domestic waste and the centralized treatment of domestic sewage at the county level, achieved good results in rural environmental treatment. There were some differences in the proportion of domestic waste and domestic sewage treated centrally in different regions. In Jingshan county-level city, Zhongxiang county-level city, Tianmen city, and Huangpi district, the proportion of domestic waste's centralized treatment by farmers was more than 90%, while in Daye county-level city the proportion was less than 90%. This indicates that the proportion of the centralized treatment of domestic waste was higher in the study area. This proportion increased in line with increasing levels of economic development, possibly because the requirements of farmers for environmental quality also increase with the level of economic development in their area. This stimulates them to perform the centralized treatment of domestic waste. The proportion of rural households that centrally treated their domestic sewage also displayed some differences. In Zhongxiang county-level city and Huangpi district, the proportion of rural households with centralized sewage treatment exceeded 70%, while in Jingshan county-level city, Tianmen city, and Daye county-level city, the proportion was less than 70%, indicating that the proportion of rural households in the research area using domestic sewage centralized treatment was higher. Similar to the centralized treatment of domestic waste and the reasons for participation, the proportion of centralized sewage treatment increased along with rising levels of economic development. However, it was difficult to obtain a convincing conclusion based only on the descriptive statistical analysis results [88], and quantitative analysis was needed to better analyze the mechanisms influencing farmers' participation in IRHS.

5.2. Quantitative Analysis

According to the theoretical analysis above, the quantitative analysis discussed in this paper was performed in the following two steps: firstly, benchmark regression was conducted to preliminarily test the influence of network embeddedness and environmental awareness on farmers' participation in IRHS; secondly, the stepwise regression method and the Bootstrap method were used to investigate the mediating effect of environmental awareness.

5.2.1. Test of the Influence Mechanism of Network Embeddedness and Environmental Awareness on Farmers' Participation in IRHS

(1) Preliminary test of core explanatory variables. Table 3 shows the regression results through the gradual introduction of explanatory variables. Only two variables embedded in the network were included in Model 1 and Model 2. The logarithmic probability function values of these two dependent variables of "rural household participating in the treatment of domestic waste" and "rural household participating in the treatment of rural domestic sewage" were -150 and -311.8, respectively, and the pseudo-R^2 values were 0.0054 and 0.0148. Models 3 and 4 introduced environmental awareness variables based on Model 1 and Model 2, respectively, and the logarithmic probability function value of the models increased to -149.5 and -290.6, and the pseudo-R^2 increased to 0.0088 and 0.0816, indicating that the explanatory power of the models was enhanced after the inclusion of the environmental awareness variables. By introducing control variables based on Model 3 and Model 4, the pseudo-R^2 values of the obtained Model 5 and Model 6 increased to 0.114 and 0.133, which further enhanced the explanatory power of the models. In conclusion, the estimation results of Model 1 to Model 6 showed that the significance and direction of the

core explanatory variables did not change significantly. This indicates that the estimation results were relatively robust. The following analysis is mainly based on the estimated results of Model 5 and Model 6.

The results of Model 5 in Table 3 indicate that the influences of network embeddedness on farmers' participation in IRHS varied greatly for each dimension. Specifically, each dimension of network embeddedness and environmental awareness did not exert any significant effect on farmers' participation in the centralized treatment of domestic waste. As a possible explanation, China is currently vigorously promoting the construction of an ecological civilization. Specifically, the government has introduced several policies and regulations to guide and encourage the protection of the ecological environment, invested in the construction of rural infrastructures, such as garbage disposal facilities, and regularly organized staff to pick up rubbish (pool). Village cadres (leaders) also inspect villages regularly and conduct additional irregular inspections. The implementation of these measures has resulted in the centralized treatment of domestic waste and sewage. Although some farmers still "litter", most farmers consciously perform the centralized treatment of domestic waste, as reflected by the descriptive statistical results. Furthermore, network embeddedness and environmental awareness had no significant effect on farmers' participation in the centralized treatment of domestic waste.

The results of Model 6 show that relational embeddedness had a significant effect on farmers' participation in the centralized treatment of domestic sewage (P-value is less than 5%), but the coefficient was negative, and the effect of structural embeddedness was close to the significance level of 10%. This indicates that relational embeddedness had a significant inhibiting effect on the treatment of domestic sewage, while structural embeddedness had a certain promoting effect. Therefore, hypothesis H1 was verified. As an explanation, maintaining a good interpersonal relationship with the surrounding farmers (the average relationship quality and relationship intensity were 0.74 and 0.79, respectively) helped to reduce the transaction cost of their information exchange and thus promoted homogeneity among their behaviors. The education level of rural households in the study area was generally not high (2.54, between elementary school and junior high school), and nearly 34% of farmers still did not participate in the centralized treatment of domestic sewage. This type of behavior involved a "demonstration effect", or, in psychological terms, a "broken window effect", which served to propagate the view that participation in domestic sewage centralized treatment is "bad" for the surrounding farmers. To some extent, however, structural embeddedness helped to encourage the farmers to participate in the centralized treatment of domestic sewage. In particular, close contact with relatives and family members, as well as with the kin and, especially, close relations between village officials, can stimulate farmers to take part in the centralized treatment of domestic sewage. Considering farmers and relatives, family members and villagers, and more closely linked village cadres, the constraints of family members and village cadres are more likely to influence farmers' behaviors. The constraints of family members are mainly reflected in the influence of influential members in the family. The constraints of village cadres are mainly reflected in the direct or indirect criticism of the non-environmentally friendly behaviors of rural households by village cadres [89]. Village cadres usually play a bridging role to connect the government and farmers and strike a balance between institutional supervision and farmers' trust. A good relationship between village cadres and farmers can promote farmers' participation in local village affairs [90]. Finally, network embeddedness can influence farmers to participate in the treatment of domestic sewage. The results of Model 6 also showed that environmental awareness had a significant positive effect on the treatment of domestic sewage. When farmers' environmental awareness is increased, their concern about the environmental quality of their surroundings increases, their willingness for and behavior toward environmental protection consciously improves, and they are more likely to centrally treat domestic sewage. In conclusion, hypothesis H2 was partially verified.

Table 2. Farmers' participation in IRHS.

District	Number of Farmers in the Sample (Households)	Farmers Participating in Centralized Treatment of Household Garbage (Households)	Farmers Not Treating Household Garbage (Households)	Percentage of Domestic Waste Centralized Treatment (%)	Farmers Participating in Centralized Treatment of Domestic Sewage (Households)	Farmers Not Treating Domestic Sewage (Households)	Percentage of Rural Households with Domestic Sewage Centralized Treatment (%)
Daye city	112	88	24	0.79	64	48	0.57
Jingshan city	80	75	5	0.94	52	28	0.65
Zhongxiang city	135	128	7	0.95	107	28	0.79
Tianmen city	79	75	4	0.95	42	37	0.53
Huangpi district	89	84	4	0.94	63	26	0.71
Total	495	450	45		328	167	

Table 3. Logit regression results of farmers' participation in IRHS.

Variable	Model 1	Model 2	Model 3	Model 4	Model 5	Model 6
	Y_1	Y_2	Y_1	Y_2	Y_1	Y_2
Relational embeddedness	0.37	−0.59 **	0.39	−0.57 **	−0.08	−0.62 **
	(0.38)	(0.27)	(0.38)	(0.28)	(0.43)	(0.30)
Structural embeddedness	0.13	0.30 **	0.10	0.17	0.18	0.17
	(0.19)	(0.13)	(0.19)	(0.14)	(0.25)	(0.14)
Environment awareness			0.21	0.90 ***	0.24	0.86 ***
			(0.21)	(0.15)	(0.22)	(0.16)
Control variables	Control	Control	Control	Control	Control	Control
Constant	1.59 **	0.15	0.91	−2.70 ***	1.22	−4.09 ***
	(0.67)	(0.46)	(0.94)	(0.67)	(1.67)	(1.05)
Number of observations	495	495	495	495	495	495
Log probability	−150	−311.8	−149.5	−290.6	−133.7	−274.2
Pseudo-R^2	0.005	0.015	0.009	0.082	0.114	0.133
Chi^2	1.631	9.353	2.654	51.66	34.24	84.46

Note: The values in parentheses are standard errors; ***: $p < 0.01$, **: $p < 0.05$.

(2) The robustness test of the core explanatory variables. To test the robustness of the baseline regression results and to consider the differences between farmers in regions with different geomorphic types (e.g., plains and mountains), this paper divided the samples into plain samples and hilly-area samples, according to geomorphic types, for further analysis. According to Table 4, the results of Models 9, 11, and 5 were relatively consistent, and the results of Models 10, 12, and 6 were also relatively consistent, namely, network embeddedness and environmental awareness had significant effects on farmers' participation in IRHS. This indicated that the results of the benchmark regression were stable. In addition, when comparing the Logit model results of Model 5 and 6 (Table 3) with the OLS model results of Model 7 and 8 (Table 4), the estimation results of the Logit model and the OLS model were consistent in terms of the size, direction, and significance of the coefficients of the variables. These results further indicated that the benchmark regression results were robust.

Table 4. Regression results of the robustness test.

Variable	**Model 7**	**Model 8**	**Model 9 (Plain)**	**Model 10 (Plain)**	**Model 11 (Hilly Area)**	**Model 12 (Hilly Area)**
	OLS	**OLS**	**Logit**	**Logit**	**Logit**	**Logit**
	Y_1	Y_2	Y_1	Y_2	Y_1	Y_2
Relational embeddedness	0.00	−0.10 *	−1.00	−2.18 ***	0.12	0.27
(RE)	(0.03)	(0.05)	(1.11)	(0.65)	(0.53)	(0.39)
Structural embeddedness	0.01	0.02	−0.21	0.29	0.57	0.12
(SE)	(0.01)	(0.02)	(0.41)	(0.23)	(0.37)	(0.14)
Environmental Awareness	0.02	0.15 ***	0.34	0.70 ***	0.06	1.05 ***
(EC)	(0.02)	(0.03)	(0.39)	(0.23)	(0.30)	(0.23)
Control variables	Control	Control	Control	Control	Control	Control
Constant	0.81 ***	−0.23	2.81	−3.13 *	0.16	−4.93 ***
	(0.12)	(0.19)	(2.71)	(1.64)	(2.25)	(1.53)
Number of observations	495	495	268	294	201	201
Log-probability	-	-	−56.86	−146.5	−68.45	−112.4
R^2	0.07	0.15	-	-	-	-
F	2.596	6.069	-	-	-	-
Adj-R^2	0.0433	0.126	-	-	-	-
pseudo-R^2	-	-	0.0618	0.201	0.175	0.150
Chi^2	-	-	7.491	73.91	28.98	39.68

Note: The values in parentheses are standard errors; ***: $p < 0.01$, *: $p < 0.1$.

5.2.2. Test of Mediating Effect of Environmental Awareness

(1) Preliminary test of mediating effect. The results of Model 6 showed that relational embeddedness had a direct negative impact, environmental awareness had a direct positive impact, and structural embeddedness had no direct impact on the treatment of domestic sewage. To further test whether network embeddedness indirectly affected the farmers' participation in IRHS through environmental awareness, it was necessary to estimate the impact of network embeddedness on farmers' environmental awareness. According to Table 5, structural embeddedness had a significant promoting effect on environmental awareness. These results indicated that environmental awareness had a complete mediating effect between structural embeddedness and farmers' treatment of domestic sewage, but the robustness of the mediating effect needed to be verified further. Furthermore, relational embeddedness only had a direct negative impact on the centralized treatment of domestic sewage.

Table 5. Impact of network embeddedness on farmers' environmental awareness.

Variable	Environmental Awareness (EC)	
	Coefficient	Standard Error
Relational embeddedness (RE)	-0.04	(0.09)
Structural embeddedness (SE)	0.07 **	(0.03)
Constant	3.00 ***	(0.29)
Control variables	Control	
Number of observations	495	
R^2	0.07	
F	2.837	
Adj R^2	0.0461	

Note: ***: $p < 0.01$, **: $p < 0.05$, *: $p < 0.1$.

(2) Robustness test of mediating effect. Compared with the Sobel method and stepwise regression method, the Bootstrap method has become a commonly used method in the testing of mediating effects [91] because it allows more accurate confidence intervals and higher testing power to be obtained [92]. Therefore, this study used this method to conduct a robustness test. The results show that the direct effect of network embeddedness on farmers' participation in IRHS was 0.130, and the P-value was 0.279, which was relatively close to the significance level of 10%. The confidence interval of the indirect effect was (0.007, 0.2715), and the P-value was 0.075. Therefore, the indirect effect was significant. In conclusion, environmental awareness had a mediating effect between network embeddedness and farmers' centralized treatment of domestic sewage thus, hypothesis H3b was verified.

6. Discussion and Policy Implications

6.1. Discussion of Findings

This paper constructed a theoretical framework for farmers' participation in IRHS based on social embeddedness theory to elaborate the mechanism underlying farmers' environmental behavior and empirically analyzed the results of the theoretical analysis to obtain the following two main conclusions.

On the one hand, relational embeddedness has a significant direct negative impact on participation in the centralized treatment of domestic sewage However, neither network embeddedness nor environmental awareness had a significant effect on farmers' participation in the centralized treatment of domestic waste. In this study, the relational embeddedness analysis consolidated some findings obtained from analysis of the farmers' social networks [64,65,69], and also provided additional quantitative results based on recent research [52]. This study also clarified the formation mechanism underlying farmers' participation in IRHS. Additionally, and surprisingly, compared with the formation mechanism underlying farmers' participation in the centralized treatment of domestic sewage, network embeddedness and environmental awareness could not explain farmers' participation in the centralized treatment of domestic waste. Because the state vigorously promotes the construction of an ecological civilization [93] and has issued many policies and regulations to guide and encourage ecological environmental protection [94,95], the state has invested in waste treatment facilities through rural infrastructure construction (e.g., organizing staff to clean up garbage ponds regularly, and regular inspections of villages by cadres). The implementation of these measures has increased the centralized treatment of rural domestic waste and sewage by farmers. Local administrative organizations, as grass-roots governments, still need to continue strengthening the input of various policy measures to better maintain the treatment of rural domestic waste and to protect the local ecological environment [96].

On the other hand, environmental awareness has a significant promoting effect on participation in the centralized treatment of domestic sewage, and structural embeddedness further influences farmers' centralized treatment of domestic sewage through their environmental awareness. Environmental awareness plays an important mediating role between structural embeddedness and participation in the centralized treatment of domestic sewage. To a large extent, the results of the current study are consistent with the analysis of environmental behavior [23] and positive environmental protection behaviors [73–77]. The research results also echo the finding that good environmental awareness will ultimately lead to good individual environmental behavior [73]. Furthermore, structural embeddedness can strongly facilitate farmers' centralized treatment of domestic sewage through their environmental awareness. This finding is in line with those of many existing studies [73,75,79,80].

6.2. Policy Implications

Based on the above results, this paper suggests the following policy recommendations: Firstly, encourage the establishment of a promotion and discussion network to involve farmers in, embed it in the local villagers' network, and strengthen the guidance of farmers' environmental behavior. As an informal relationship network, the villagers' network has the characteristics of "homogeneity", "locality", and "atomicity". It is suggested that farmers should support exchanges and studies among themselves and to encourage them to integrate themselves into the "heterogeneity" network of rural elites, we will give full play to the role of the rural relationship network (especially the village cadres and rural elites) in promoting their participation in IRHS. Secondly, support education and dissemination of environmental knowledge among rural households and increase especially the supply of environmental knowledge to rural households in hilly areas; through the network, television, and other channels, increase the publicity of rural environmental protection and enhance their responsibility and awareness of environmental protection. Furthermore, increase the overall level of farmers' environmental awareness in China to stimulate more farmers to participate in IRHS. Thirdly, strengthen the relationship between farmers, family members, and village cadres, which can promote participation in domestic sewage centralized treatment. Closer relationships between farmers, family members, and village cadres as well as higher levels of their environmental awareness can progressively promote their participation in IRHS.

7. Conclusions

This paper focused on the analysis of farmers' participation in improving rural human settlements (IRHS) from two perspectives: the centralized treatment of domestic waste and domestic sewage. The influence of network embeddedness and environmental awareness on farmers' participation in IRHS was discussed, and an empirical test using the survey data of 495 rural households in Hubei Province was conducted. The research conclusions are as follows: firstly, relational embeddedness can effectively promote farmers' participation in domestic sewage centralized treatment. Because of restrictions deriving from many sources, farmers' relational embeddedness negatively influences their participation in the centralized treatment of domestic sewage. To some extent, this indicates that relationship embedding can effectively promote farmers' participation in the collective action of improving rural human settlements. Secondly, environmental awareness can effectively promote farmers' participation in the centralized treatment of domestic sewage. The promoting effect on the centralized treatment of domestic sewage increases along with the environmental awareness of farmers. To some extent, this indicates that environmental awareness can effectively encourage farmers to participate in the collective action of improving rural human settlements. Finally, structural embeddedness further promotes farmers' participation in the centralized treatment of domestic sewage by improving their environmental awareness. Environmental awareness plays an important mediating role between structural embeddedness and the centralized treatment of domestic sewage. To some extent, this indicates that structural embeddedness can further promote farmers' participation in the collective action of improving rural human settlements through enhancing environmental awareness.

Despite its valid contributions, this study has certain limitations and unanswered questions that require further study. Firstly, although the study area was only located in central China and the random sampling method was adopted to obtain the data to minimize sampling bias, the sample size mainly covered two important typical geomorphic types (e.g., plains and mountains), similar to the geomorphic types in other countries (e.g., the United States and Brazil). Therefore, although the interpretation of the results should be cautious, they can be generalized to other developed and developing countries. The importance of these results may be reinforced by the fact that they varied widely among farmers in different geographical settings. Secondly, exploring the corresponding consequences of farmers' participation in IRHS would be a natural extension of this study. Specifically, future research should investigate the social, economic, and ecological effects of farmers' participation in IRHS. Thirdly, this paper mainly employs social embeddedness theory to analyze the mechanisms influencing farmers' participation in IRHS. Nevertheless, specific types of network embeddedness not only affect farmers' behaviors but also play important roles in the formation of combinations. Since this study did not provide a detailed analysis of these combinations of types of network embeddedness, it is not clear which combinations are most suitable to motivate farmers to participate in IRHS. To address the deficiency of traditional regression analysis, which only analyzes the net effect, future research should explore the mechanisms through which networks influence farmers' participation in IRHS from the perspective of network configuration. Finally, the concept of IRHS is broad. Although based on the actual situation, this paper mainly focuses on the centralized treatment of domestic waste and domestic sewage centralized treatment; other aspects of IRHS can be further explored in future studies.

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Notes

1 During the process of investigation, it appeared that some farmers may treat centralized and non-centralized domestic waste and domestic sewage. Farmers dealing with domestic waste and sewage might not only carry out centralized treatment but also occasionally dump waste or dirty water. In this study, performing centralized and non-centralized treatment simultaneously was considered as not participating in IRHS. Due to the restrictions of past living habits and other factors, there are still some environmentally unfriendly behaviors among farmers, which cause some damage to the environment. Therefore, this behavior is still regarded as not participating in IRHS.

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Article

China: A New Trajectory Prioritizing Rural Rather Than Urban Development?

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Abstract: The adverse effects of rapid urbanization are of global concern. Careful planning for and accommodation of accelerating urbanization and citizenization (i.e., migrants gaining official urban residency) may be the best approach to limit some of the worst impacts. However, we find that another trajectory may be possible: one linked to the rural development plan adopted in the latest Chinese national development strategy. This plan aims to build rural areas as attractive areas for settlement by 2050 rather than to further urbanize with more people in cities. We assess the political motivations and challenges behind this choice to develop rural areas based on a literature review and empirical case analysis. After assessing the rural and urban policy subsystem, we find five socio-political drivers behind China's rural development strategy, namely ensuring food security, promoting culture and heritage, addressing overcapacity, emphasizing environmental protection and eradicating poverty. To develop rural areas, China needs to effectively resolve three dilemmas: (1) implementing decentralized policies under central supervision; (2) deploying limited resources efficiently to achieve targets; and (3) addressing competing narratives in current policies. Involving more rural community voices, adopting multiple forms of local governance, and identifying and mitigating negative project impacts can be the starting points to manage these dilemmas.

Keywords: China; dilemmas; global leadership; national development strategy; policy implementation; rural revival and development; urban and rural development

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1. Introduction

Today, more than half the world's population lives in urban areas, a proportion that is expected to increase to 66% by 2050, and the number of cities in developing countries will have tripled by 2030 [1,2]. Large-scale urbanization has been happening autonomously and has been actively advocated by individuals, collective powers and states since the 19th century [3,4]. Cities are now the main centers for technology development, innovation, education, commerce, administration, transportation, medical care, human resources and more, and around 80% of global gross domestic product (GDP) is generated in cities [4,5]. Some urbanization researchers and proponents have argued that more than 99% of humans will live in cities by the end of this century and that the valuing and planning of rural areas should focus on urban needs [6,7]. Some even regard rural areas as places that are suitable only for growing crops and keeping livestock [8–10].

Despite the benefits of urbanization, it is the ecosystem, rural areas surrounding cities, and rural people who are paying for rapid development with environmental degradation and social inequities [11,12]. Under political pressure to satisfy urban residents—who now often form large and economically powerful blocks—central governments have favoured urban areas and urban populations at the expense of rural populations. This is evident in suppressing prices of agricultural products, investing in urban industries and providing more generous and higher quality public services like transportation, health and education in cities [11,13]. Attracted by the higher income and greater opportunities that cities provide, and pushed by the growth of industrialized agriculture, many poor rural people migrate to urban areas temporarily or permanently as laborers [4,13,14]. However, these incoming rural people do not enjoy the benefits of city life as much as other urban dwellers. Although constituting nearly one-third of the urban population in developing regions (i.e., around 863 million), rural-to-urban migrants often live in slums or informal settlements, in housing that is usually non-durable, overcrowded, and without adequate clean water, health care, sanitation or social security [4]. People still living in rural areas also endure a harder life than urban residents [15–17]. Rural withering has been hard to stop, and many scholars are concerned about the future of rural areas, including such aspects as isolated farming communities [18,19], rural youth out-migration [20,21], farm land degradation [10,22], children and women left behind [21,23], limited access to resources and services [13,24], excessive construction and severe pollution [25], and vulnerability to disasters [26,27]. Obviously, supporting rural communities matters for achieving sustainable rural development.

As the country used to have the largest rural population in the world, China has enjoyed the great benefits but also the negative consequences of high-speed urbanization [1,28–30]. The GDP per capita has increased from 1,378 yuan in 1988 to 69,876 yuan in 2019, a 51-fold increase [31]. However, fast development is not always desirable because of its adverse outcomes, such as the increasing wealth gap [32,33]. Figure 1 shows that the annual average income gap between urban and rural residents is increasing; the income of urban residents (i.e., 42,359 yuan) in 2019 was 2.65 times that of rural residents (i.e., 16,021 yuan). Real estate sales support China's rapid urbanization [34] but at the cost of rapidly increased housing prices; the high-debt real estate market has become the largest 'grey rhino' in China [35]. Household debt by the end of 2018 in China was 60.4% of China's GDP, and the household debt-to-income was over 99.9% [36]. This high debt has raised concern from global investors at the risk of a credit crisis [37]. Moreover, cities have been epicenters of COVID-19 [38], and many scholars have proposed a review of urban design, planning and management to achieve a society more resilient to future pandemics and disasters [39,40]. Government commitments to ensure both rural residents' and rural-to-urban migrants' livelihoods and their aspirations for a better life during the process of rapid urbanization have been questioned [29,41–43]. Although the Chinese government has insisted on putting people at the center of their policies, some assessments find that governments have focused on stabilizing their power and gaining revenue by prioritizing land exchange, agglomeration, and development [29,44–46].

In light of the inertia of prioritizing urban areas, urban researchers emphasize the need for China to put more effort into protecting migrants when speeding up urbanization and citizenization (i.e., migrants gaining official urban residency) [29,48–50]. In September 2018, China published the *Strategic Plan of Rural Development (2018–2022)* ("the plan"), aiming to prioritize the development of rural rather than urban areas [51–53]. On top of this, the Rural Development Promotion Law was approved by the Standing Committee of the National People's Congress [54] on 29 April 2021. The law is probably the first one in the world legitimating rural development with such a command-and-control policy instrument [55]. The policy change in China from favoring urbanization to favoring rural development has surprised many scholars [30,49,56–58], but critical analysis on why it happened is limited. Consequently, we address possible motivations behind this choice by addressing the following three questions:

What are the possible strategies to revive and develop rural communities sustainably? (Q1)
What socio-political drivers have led to China choosing to develop rural areas now? (Q2)
What are the possible dilemmas, and how can China cope with them? (Q3)

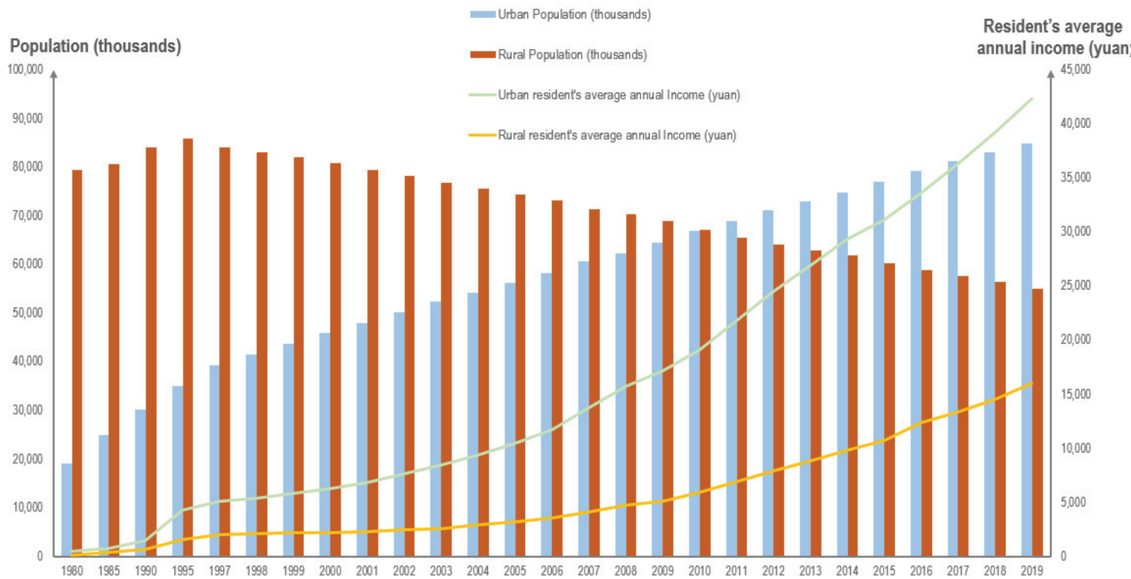

Figure 1. Population and income change of urban versus rural residents (Source: [47]).

2. Materials and Methods

To answer the above questions, this paper investigates the policy process of the plan by applying the three policy process theories, which are policy analysis, policy change via advocacy coalition framework, and implementation analysis [59]. To answer Q1, we conduct policy analysis by evaluating policy implications and options proposed by various scholars in international publications on sustainable rural development to understand past experiences and inform current decisions (Section 3.1) [59,60]. To answer Q2, we use the advocacy coalition framework to explore the socio-political drivers of China's choice to develop rural areas (Sections 3.2 and 3.3) [61–64]. To answer Q3, we discuss possible dilemmas and several feasible solutions and recommendations based on the determinants of success for policy implementation effectiveness outlined by Knill and Tosun (Section 4) [65].

Evidence used to support the above analysis is based on an extensive literature review of high-quality publications in English and Chinese and our field research in rural China from 2016 to 2020. Primary empirical data was collected by the authors' investigation on sustainable livelihood conditions of rural people subject to various projects in Yunnan, Guizhou, Sichuan, and Chongqing, such as "beautiful countryside", dam-induced resettlement, poverty-alleviation resettlement, and agglomeration-of-villages (*合村并居*). Nine villages were visited and 56 rural residents were interviewed; these included peasants, migrant laborers, fishermen, restaurant owners, chefs, builders, small-business owners, cattle farmers, coffee planters, tea processors, chili planters, poets, and painters (more information can be found in the Supplementary Material Table S1).

The literature is reviewed in four steps. We first review the latest research discussing the impacts of urbanization and the further treatment of urban–rural relationships in the Web of Science Core Collection and China National Knowledge Infrastructure (CNKI) (17 November 2020). The following search equation used: ("rural development" OR "rural revitali*ation" OR "rural vitali*ation" OR "develop* rural" OR "rural revivification" OR "reviv* rural" OR "rural resurgence" OR "revitali* rural" OR "resurg* rural") AND (urban* OR urbanisation OR urbanization OR citizen* OR urban-and-rural OR urban-rural OR "integrat* urban and rural" OR "integrat* rural and urban"). Second, we summarize the main viewpoints of the treatment of urban–rural relationships, synthesize the traditional trajectory of sustainably developing rural areas, and compare it with the new trajectory proposed by this case study [51]. Third, we examine the rationale of the new trajectory by assessing its design's suitability to China's current conditions by reviewing the latest journal articles, master's and doctoral theses, books, conference papers, and newspaper articles in the CNKI database (available at https://cnki.net/, accessed on 17 November 2020) from 2016 to 2020 via terms "*乡村振兴*". In addition, we examine the arguments on agriculture and rural development by assessing the National Bureau of Statistics (available at http://www.stats.gov.cn/tjsj/, accessed on 11 April 2019), agriculture and rural development indicators from the World Bank (available at https://data.worldbank.org/indicator?tab=all, accessed on 11 April 2019), and land and agriculture data from the United Nations Statistics Division (available at: https://unstats.un.org/unsd/environment/Time%20series.htm#LandAndAgriculture, accessed on 11 April 2019). Fourth, this study assesses the challenges of implementing the plan in practice based on available secondary empirical data. Secondary data, such as the strategic plan of rural development, the 19th Congress Report, and implementation of some policy interventions (i.e., poverty alleviation, beautiful countryside, and dam-induced resettlement) were obtained from a selection of available sources, including books, e.g., [41,66], environmental impact assessment reports, e.g., HEC [67], available on-line theses, e.g., Ding [68], five-year plans, e.g., [51,69], regulations, e.g., [70,71], news, e.g., [72–74], and journal articles available through Google scholar and CNKI, e.g., [75–78].

3. Results

3.1. Theory: Rural Withering and Three Future Scenarios for Urban–Rural Relationships

Rural "withering" is a negative outcome in countries with rapid or a high degree of urbanization [18,21,24]. This phenomenon involves poor rural education, children left behind as their parents work in cities, empty-nest elderly residents, poverty, powerlessness, and isolation [15,17,25,66,79–81]. Moreover, rural residents enjoy fewer public services and employment opportunities than urban residents [13]. Out-migration of rural residents to cities happens for employment opportunities, better education, and health care [20,25]. Urbanization may appear to be the ultimate destination of humanity, with one scenario for the end of the 21st century projecting that over 99% of people will be urbanites [7]. In China, the total number of villages has declined from 4.20 million in 1984 to 2.67 million in 2012, with 55,000 villages disappearing each year [81]. It seems that rural withering is unavoidable due to development, and rural residents need to be relocated [28]. To explore strategies on how to revive and develop rural communities sustainably (Q1), we summarized two scenarios that represent mainstream views and proposed a new one inspired by China's rural development strategy.

3.1.1. Scenario 1: Urbanization, De-Agrarianization, and Corporate and Entrepreneurial Farming

Viewpoint: Cities are in a predominant position, and rural areas are used for growing food [6–10].

In this scenario, urbanization and capitalist expansion, together with processes such as globalization and climate change, make de-agrarianization and de-peasantization (e.g., death of family farms) inevitable results of development [8,10,18,82]. Rural development is subordinate to urbanization, and policies aim to support sustainable transition or transformation from rural to urban lifestyles.

In rural areas, increasingly industrialized agriculture degrades the relationships between farming, nature, locality, and community and pushes rural people off their land to a marginal life in cities [10,14,21]. Additionally, few people live a peasant-like rural life because most non- or pre-capitalist forms of production no longer provide sufficient income or employment opportunities [10,21]. On the other hand, increasing urbanization reinforces non-farm growth rather than supporting slow-growing agriculture in rural areas, because non-farm growth can offer a pathway out of poverty for the rural poor with low capital input and requires less government investment [25,83]. The proportion of the global population not producing food keeps growing, as does the number of middle- and high-income consumers of foods that are more energy- and greenhouse gas emission-intensive (e.g., meat consumption per capita is higher in urban areas) [83]. This demand requires more efficient agriculture supply chains, and land owned by the rural poor is not productive enough to meet demand chains [22,84]. As a result, policies for and investment in farming and agriculture are likely to support agrarian entrepreneurs geared to the demands of the market rather than local people [84–87].

3.1.2. Scenario 2: Urbanization, Rural Revitalization, and Re-Agrarianization

Viewpoint: Cities are still in the dominant position, but urban communities support the cultural relationships that rural people attach to their environments. Rural development is reoriented from productivism to multifunctionality [7,10,18,88,89].

In this scenario, living in cities is not the dream of all human beings, and cities cannot provide all needed and desired services to meet humanity's needs [7,90–92]. Specifically, annoyed by the crowded, noisy, and unhealthy urban lifestyles, increasing numbers of rural-to-urban migrants, or even urban residents, return to settle in rural areas to revitalize local agriculture, economy, and education [93]. In addition, increasing numbers of families choose to live in exurban areas to enjoy rural experiences despite their need to travel a longer distance to work every day [94]. They develop new forms of rural lifestyles [12,88,91,95,96]. Gradually, rural revitalization increases, as rural livelihoods entail more than simply growing crops or keeping livestock [97]: they are based on thousands of years of knowledge and experience of how people live with the land and nature, including knowledge of local farming, cultural landscape, language, customs, and arts [10,42,98]. Furthermore, small-scale, organic, or family farming can offer more choices than industrialized agriculture [10]. Thus, more attention, appreciation, and support is given to rural development, focused on the value of rural areas, including land consolidation, landscape use transition, rural tourism, food, heritage, and authentic products (i.e., a focus on quality) [89,99]. Peasant-like agricultural systems and lifestyles persist, despite the strong push of de-agrarianization and the movement toward corporate and entrepreneurial farming [100,101].

3.1.3. Scenario 3: The Traditional and the New Trajectories to Sustainably Develop Rural Areas

Viewpoint: Sustainable rural development should engage rural and urban communities in a united structure (Figure 2), where each of them can have comparable infrastructure and public services and can be equally attractive while representing different lifestyles.

Rural communities are withering as a result of urban development, and cities are becoming central to humanity as a result of globalization, industrialization, urbanization, and capitalist expansion [102]. Although some rural elements remain important for human development, the attitude to rural development may be limited to revitalization [99]. Vibrant rural communities seem destined to be a secondary objective rather than a priority in the context of urban development [10]. Thus, rural withering may be unavoidable, but more focus should be put on investigating how rural communities and rural-to-urban migrants can better serve urban needs while keeping their beneficial characteristics [32,93,103–107].

Is there any other new scenario that can solve this problem? We argue that Scenarios 1 and 2, following the traditional trajectory of sustainably developing rural areas, fail to consider urban and rural areas as a united system with the same development rights [76,108–111]. We suggest a new scenario, which entails developing rural areas as a new attraction while representing different lifestyles (Figure 2). For example, China aims for equality in sustainable development among rural and urban areas without sacrificing rural areas and communities [51,52]. Some urban scholars overlook the fact that dynamic processes exist between rural residents and rural-to-urban residents and consider that rural-to-urban migration is unidirectional [112]. As Van der Ploeg and Ye [41] point out, currently, Chinese peasants have multiple roles: they are peasants during the growing and harvest seasons and migrant workers at other times. In 2017, more than 73.2% of peasant workers chose to work locally or in their province [113]. However, an estimated 286.5 million peasant workers in China in 2018 changed roles over time [113]. Push–pull powers co-exist, meaning that some people move from rural to urban areas, whereas others move in the opposite direction [112]. For example, an increasing number of migrants (e.g., 4.8 million in 2016 versus 4.4 million in 2015) have been returning to rural areas since 2012 [114–116].

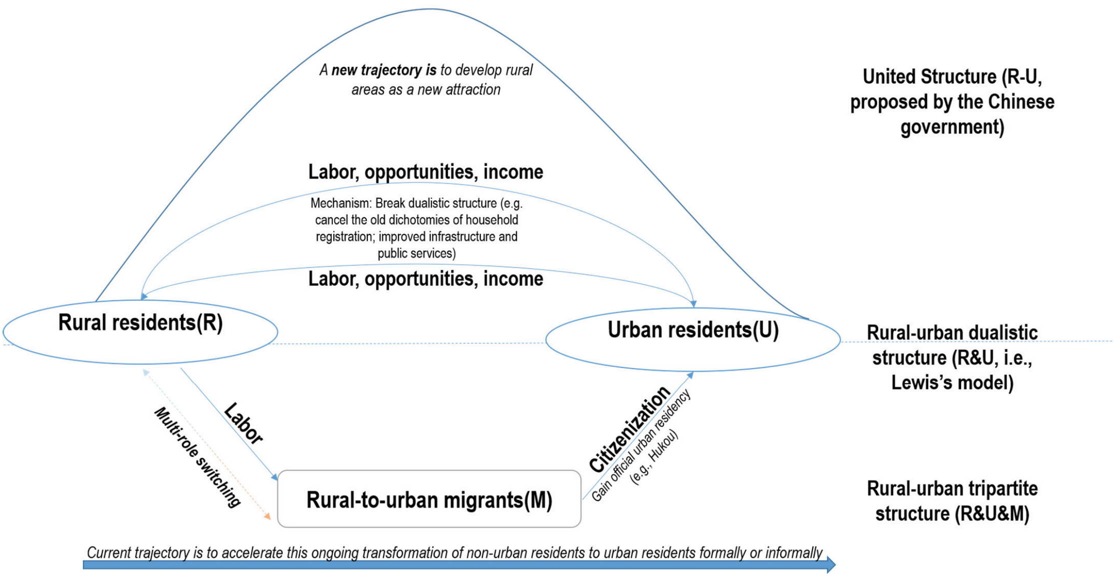

Figure 2. Trajectories to solve the negative impacts of rural development. Source: authors.

So, why do rural-to-urban migrants choose to work in, keep close contact with, or return to such an undeveloped, unproductive rural area with few employment opportunities, as Lewis [108] defined? We do not have all the answers but can conclude that rural areas may be as attractive as urban areas or that urban areas have become less attractive [117,118]. For example, in China, the attractiveness of urban areas for rural communities has declined since the mid-2000s because of fewer employment opportunities and a hard-to-access urban welfare system [116]. Instead, the attractions of rural areas could be home, families, friends, childhood, community, memories, beliefs, a sense of security, and other benefits [119].

By following the traditional trajectory and being trapped in Scenarios 1 and 2, concerns of "bad governance" raised in many studies indicate the poor performance of governments in managing the needs of rural residents and migrants [29,32,120]. However, most scholars favor urban development [84,121,122]. Urban researchers regard rural residents (i.e., the subsistence sector) as prospective underemployed laborers available to "serve" cities, and urban residents (see Figure 2) [109]. The aspiration for a better and happier life for people living in rural areas is the ultimate driver to push them to move to cities [14,29,50]. From this perspective, in China, a special group of people is emerging: rural-to-urban migrants who are not rural residents nor "qualified" urban dwellers [121,123]. They have become the new burden of urbanization [124]. Because it meets both the needs of urban and rural residents, the ultimate way to handle this group of people is to speed up citizenization [125], a process of changing the status of non-urban residents to urban residents (e.g., *hukou 户口*, official urban residency) or empowering non-urban residents with almost the same rights as urban residents when living in cities (e.g., *juzhuzheng 居住证*, temporary residency) [50,85,120,126]. By doing this, urban residents can enjoy more stable living conditions, free from the insecurity of migrants, while benefitting from cheaper rural resources with modern and industrial agriculture [10,29,86,100]. Also, rural-to-urban migrants and potential migrants living in rural areas can enjoy a more prosperous life by living in cities, because small-holder farming in particular is no longer the best way to improve the income and livelihood of rural residents [85]. During this transition process, two groups of problems are emerging: problems caused by the flow of people from rural areas to cities [20] and the loss of people in rural areas [24]. For example, many scholars use Lewis's model, which considers urban and rural areas as a dualistic structure (Figure 2), and follow the trajectory of urbanization-led success in development, to examine and assess the problems of urbanization, peasant workers, and rural residents [7,50,76,108,127–129].

By following the new trajectory, the following sections introduce why (Q2) and how (Q3) China seeks to sustainably develop rural areas.

3.2. China's Rural Development Plan

In September 2018, the Chinese Government published the *Strategic Plan of Rural Development (2018–2022)* ("the plan"), aiming to prioritize the development of rural rather than urban areas in the next 30 years [51–53]. This means that by 2050, rural and urban areas could have the same infrastructure and public services (Figure 3) and be equally attractive while representing different lifestyles. One example is the Chinese reform of the household registration system (*hujizhidu 户籍制度* or *hukou 户口*), which started in 2014 and committed to removing the old dichotomy of rural and non-rural residents by 2020 (Figure 2) [130,131]. In addition, China has put huge efforts into improving infrastructure and public services in rural areas (Supplementary Material Table S2). For example, over 96.7% of villages in China have been connected with sealed roads [51,132].

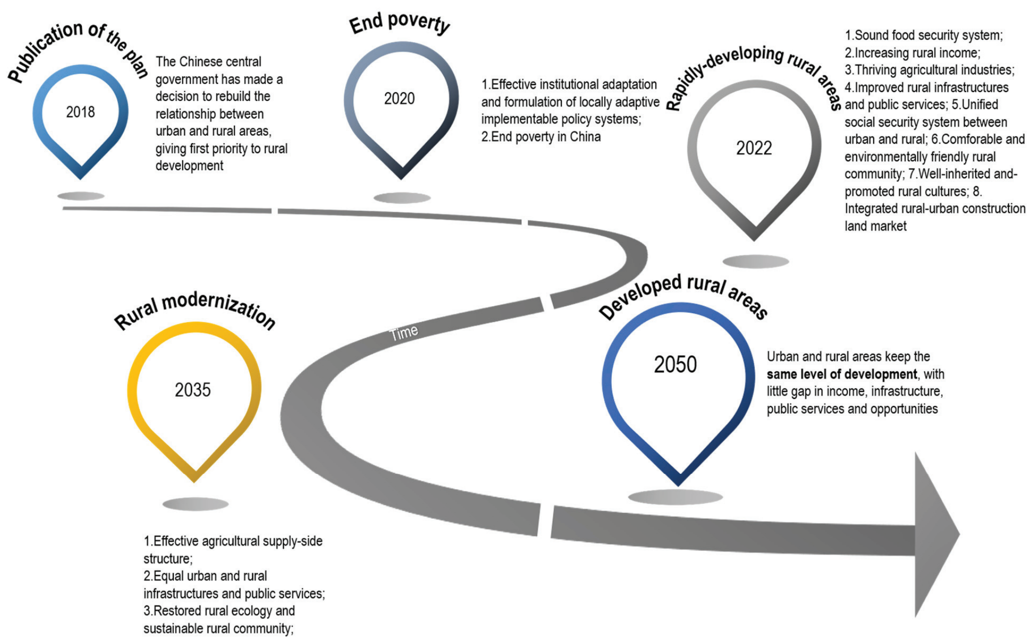

Figure 3. Milestones and goals of China's rural development strategy. © authors (Source: State Council [51]).

In short, China is trying to rebuild the relationships between rural and urban areas in a new approach: unification, rather than transition. The plan sets four milestones and 22 goals (Supplementary Material Table S2) to help rural industries, ecological rehabilitation, and community development in rural areas, and achieve sustainable development goals [133–135]. The plan aims to help implement the latest national strategies, in particular, the "China Dream" [136] and "Ecological Civilization" [137]. It also proposes to remedy existing problems and potential risks associated with rapid urbanization that have not been addressed in the National New-type Urbanization Plan [29,138].

While China's rural development strategy is possible in theory, it will not be successful if it fails to be relevant to national or local contexts or lacks detailed planning for sound implementation [65]. To assess the strategy's feasibility in practice, the socio-political drivers and deployment of the plan based on current Chinese socio-economic conditions (Section 3.3) and the challenges of implementing the plan in practice (Sections 4.1–4.3) are addressed below. Based on the identified challenges, several options to enhance the effectiveness of plan implementation will be discussed (Sections 4.4 and 4.5).

3.3. Socio-Political Drivers of the Plan

Public policies are shaped not by any single individual in a political system but by various complicated interactions among different actors within nested policy subsystems [61]. Policy subsystems describe the area and topical focus of policy issues of a political system within a geographic scope [139]; they are the primary unit of analysis of the advocacy collation framework [64,140]. By exploring the policy subsystems of a newly emerging issues with the application of the advocacy coalition framework, it is possible to better understand possible socio-political drivers and pathways of policy change [141–143]. The framework was developed by Sabatier and Weible [61] to assess "wicked" problems involving substantial policy change and competition among multiple actors. It has been applied to different political systems in many countries [61,140]. Rural and urban development in mainland China is the selected policy subsystem here.

To explore the socio-political drivers of the plan (Q2), we follow two critical paths—policy-oriented learning and external perturbation—in the framework to uncover China's policy change from speeding up urbanization to developing rural areas [56,61,143]. Policy-oriented learning describes the enduring alterations resulting from policy feedback within the policy system, despite external perturbation and shocks, such as changes in socioeconomic conditions, disasters, and redistribution of resources, to the policy system [56,61]. By following the two paths, we identify five socio-political drivers (Figure 4) to discuss China's choice of developing rural areas.

3.3.1. Ensuring Food Security

A food security system is needed while opening the Chinese domestic market to international markets, as illustrated by the effects of the US–China trade war and COVID-19 pandemic [56,144,145]. Facing the uncertainties and instability of international trade in agricultural products, such as blocked exports, decreased yield, and disrupted production cycles [146], China has set up a national food security strategy. This strategy has five requirements: being self-sufficient, fulfilling domestic demands, achieving high yield, reducing imports, and enhancing agricultural technology. For example, to maintain the quality and quantity of land, the plan has adopted the "red line of arable land", with targets for protecting 120.0 million hectares of arable land, including 103.1 million hectares of cropland, before 2020, with another target for an additional 66.7 million hectares of high-quality cropland with advanced irrigation systems before 2022 [51,147].

3.3.2. Addressing Overcapacity

Infrastructure development in China has contributed significantly to economic growth since the late 1970s because it has helped export-led economic growth, attracted private and public investments, and provided employment opportunities [148]. However, fast growth and its dependence on infrastructure construction (*jijiankuangmo 基建狂魔*) [149] have led to investment in many types of infrastructure (e.g., road, railway, and telecommunication) and base products (e.g., steel) that exceed demand [150], inefficiencies that have detracted from rapid economic growth [151]. Moreover, the land financing strategy adopted by local governments has triggered more excessive infrastructure construction [151,152], especially housing in "ghost cities" [50]. To stabilize its economy in response to declining exports due to the China–US trade war [153,154] and COVID-19 pandemic [155], China continues to invest in infrastructure construction [37,153–155]. Rural areas can be places for new investments in infrastructure and consume part of the infrastructure development and base products production overcapacity [156,157]. Consequently, rural areas can enjoy new and improved infrastructure, including roads, telecommunications networks, and dams, as well as improved public services, such as schools, hospitals, and village administration [157,158].

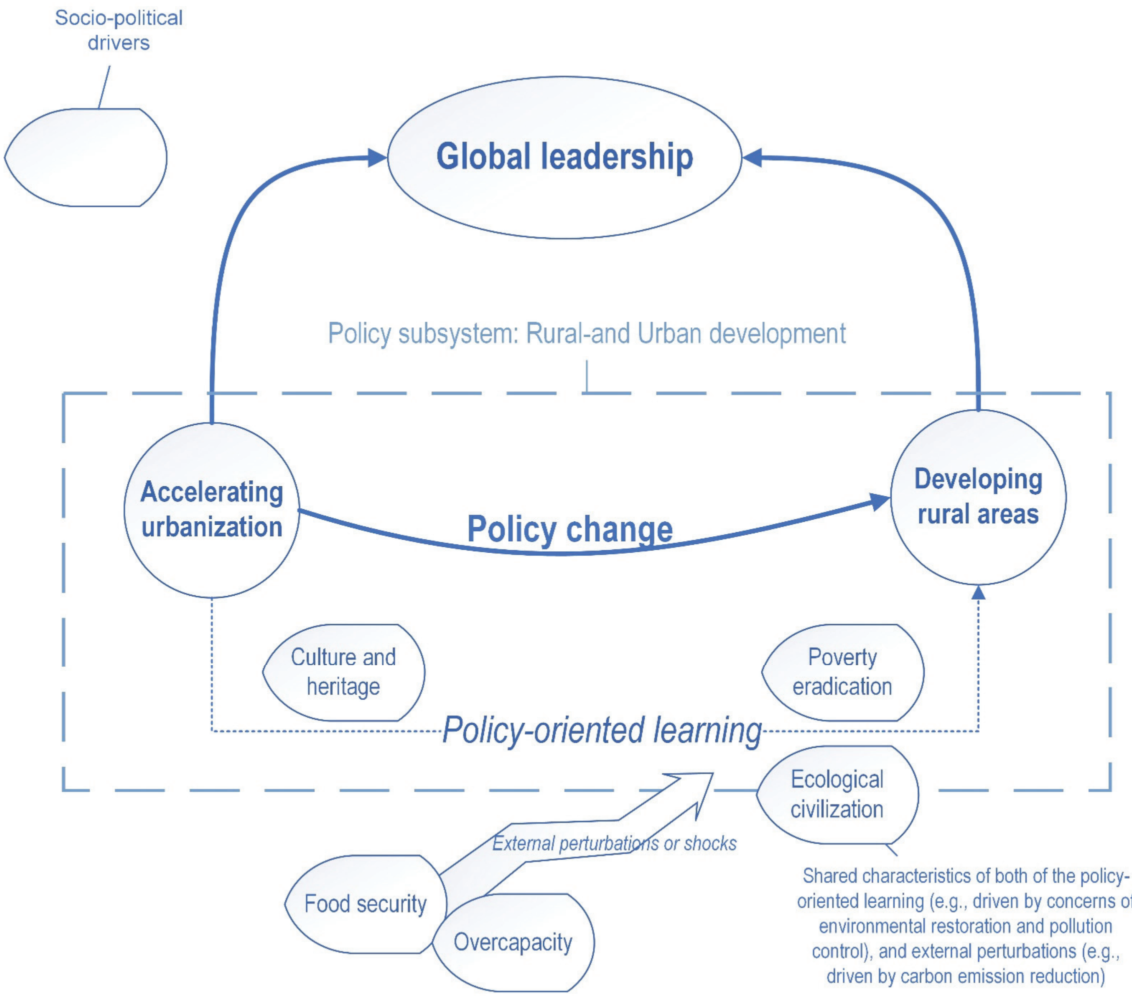

Figure 4. Policy change from accelerating urbanization to rural development and five socio-political drivers (Source: authors).

3.3.3. "Eradicating" Poverty and Enriching Rural Communities to Stabilize the Party's Legitimacy

Long-term income inequality (Figure 1) and unequal development caused by rapid urbanization mean that most of the poor in China live in or come from rural areas, and they have become the main targets for policies to eradicate poverty [159,160]. More than 200 million people, mainly young and middle-aged adults, have migrated from rural areas [161]. This has resulted in a loss of high-quality land, land tenure insecurity, left-behind children (around 22 million), empty-nest elderly residents, and abandoned settlements [41,162]. As rural areas have been regarded by the Chinese Communist Party as the root of its legitimacy [163] since the 1930s, the emerging rural withering starts to threaten the party's legitimacy [164]. Consequently, investments to improve the livelihoods of rural communities enhance the party's legitimacy in rural areas and among the poor [132,165,166]. For example, with improved infrastructure, the number of villages selling agricultural products online, mainly via Alibaba (i.e., Taobao) and Pinduoduo, has increased significantly since 2009. From three villages in 2009, 3202 villages sold produce in 2018, contributing more than 28.53 billion yuan in domestic consumption that year [167,168]. Moreover, 357 out of 592 national-level counties in severe poverty are located in isolated regions, and their residents have relied greatly on e-commerce to sell their products [169,170]. Such achievements in poverty eradication were promoted by Xi Jinping on 25 February 2021 [171], emphasizing the party's contribution and consolidating its legitimacy.

3.3.4. Protecting and Building Cultural Heritage to Support "Great Rejuvenation"

China's rural development plan has also contributed significantly to support Xi Jinping's dream of "great rejuvenation" by adopting cultural heritage to project soft power [133,172]. Chinese history has been selected, constructed, and adjusted by the party since 1949 to achieve many political goals [173]. For example, the party has stabilized its power and united the nation by emphasizing China's five-thousand-year-old civilization [133]. The promotion of China's historical role as a global leader is used to gain current and future influence in global cooperation and competition [133]. Chinese history originated from farming culture along the Yellow and Yangtze rivers around 10,000 years ago [174,175]. Chinese beliefs, culture, and knowledge are rooted in rural areas; for example, the land and soil are regarded as the mother of all creatures in traditional Chinese culture [176,177]. In addition, Chinese rural communities have great diversity in ceremonies, architecture, customs, languages, lifestyles, arts and crafts, diets, and other cultural habits (Figure 5) [51,158]. Photos in Figure 5 show aspects of the rural cultural heritage of the Dai, Yi, Wa, Yi, and Miao people in Yunnan and Guizhou provinces. Most of these cultures are thousands of years old and thus have high cultural, social, economic, and ecological value. For example, the *Om Din* village (top right, bottom middle, and bottom left) is the last in China that maintains an aboriginal tribal culture [178], and *Bing An* (bottom right) is the largest collective village that retains extensive historic military, commercial, and transportation infrastructure [179]. Consequently, protecting rural cultural heritage can contribute to China's soft power and show the party's respect for the rights and interests of ethnic minorities.

3.3.5. Ecological Civilization as China's Green Deal

After Xi's speech stating that "lucid water and lush mountains are invaluable assets" (*lvshuiqingshan jiushi jinshanyinshan 绿水青山就是金山银山*) in the 19th National Congress Report in 2017, China has sought to become an "ecological civilization" as shown in Figure 6 [134,180], which could be understood as "environmental protection is of the utmost priority" [181,182]. Ecological civilization has been interpreted as sustainable development with Chinese characteristics [183,184], but few scholars have assessed the policy's contribution to support China's current and future global leadership by promoting efforts to conserve the earth [134,185]. "Ecological civilization" has formally been embedded in every Chinese development plan as a principle [185,186]; however, few researchers recognize that the concept has been embedded in rural reconstruction and development policies since 2007 [184]. Developing rural areas can improve the living conditions of rural residents and also contribute to China's international policy priorities [187,188]. For example, increasing vegetation coverage and transitioning to clean energy (Supplementary Material Table S2), as specified in the plan, are designed to contribute to China's climate change mitigation plans.

Figure 5. Rural areas maintain many aspects of the cultural heritage of China (photos© authors).

Figure 6. Government billboard promoting ecological civilization as China's green deal to enhance the nation's reputation and contribute to its global leadership (source© authors). Translation: Xi Jinping says: "Ecological civilization matters for China's permanent development and great rejuvenation. Improved ecological conditions bring us a more civilized society. We are now facing severe stress on the way to achieving ecological civilization but I believe that China has the ability to sort out any challenges we meet." (photo© authors).

4. Discussion

Intuitively, from a political perspective, the plan is designed to meet China's political objectives domestically and bolster its aspirations for global leadership. The plan supports economic growth and maintains national security while respecting rural residents' choices and protecting rural culture [101,189,190]. To safeguard its economic rise, China has to interweave its capital markets with global finance [165,191]. However, increasingly coupling with global financial markets may challenge the dominant role of the party. To consolidate the party's central role in managing people and resources while opening China's capital markets, a range of measures have been adopted [192] in areas such as food [193], domestic and global capital markets [194], supply chain [195], and censorship [196]. As we illustrated in Section 3.3, the policy change in China from favoring urbanization to favoring rural development can enhance China's control of many policy problems while opening its capital markets [190,195,197].

However, developing rural areas requires the input of a great number of resources and changes existing institutional arrangements, which triggers new dilemmas [198]. Based on our literature review and field work in rural China from 2016 to 2020, we find three main dilemmas in putting the plan into practice based on examining China's rural development experiences according to determinants of success for policy implementation effectiveness outlined by Knill and Tosun [65] (Q3).

4.1. Dilemma 1: Central Supervision Versus Decentralization in Policy Design

As a top-down authoritarian system, policies initiated by the central government always engage governments at provincial, municipal, and county levels in policy design [157,199]. Local governments are always required to react to the policies of the central government by developing and implementing relevant programs [200]. The central government needs to make sure the policies are implemented well through supervision [201]. However, there are gaps between national priorities and local interests, and many local governments will choose to react with inaction or even adversely [202,203]. Monitoring alone cannot reduce the odds of poor implementation, and it may increase the tendency to undertake token actions that meet targets required by higher authorities but create few social benefits [65]. Moreover, Knill and Tosun [65] point out that when specialized knowledge is needed to implement public policy, the more likely it is that local government implementers will have an advantage over central policymakers, resulting in deviations from the original policy.

For example, as one of the five socio-political drivers, poverty eradication policies in rural China appear to have been extremely successful. China has successfully lifted 730 million people out of extreme poverty since 1978, and the government declared that extreme poverty was eradicated by the end of 2020 [204]. However, the statistics for poverty eradication may not represent actual conditions in many areas of China, especially in "frontier" areas such as some villages in Yunnan Province [205]. An interviewed villager (P42) reports "local government officials hire their families and friends to disguise themselves as successful people who used to live below the poverty line and are now out of poverty". Other forms of poor governance include local government officials who allocate poverty eradication funds to family and friends rather than to people enduring serious poverty; diverting the funds meant for poverty eradication to other projects, where they may get kickbacks; submitting a false number of local residents' applications for income; and failing to develop local projects and instead distributing the money directly to the poor [206,207].

Unfortunately, implementation of the concepts of ecological civilization [184,208], beautiful countryside construction [209], and agglomeration of villages [210,211] to develop rural areas have often involved the demolition and reconstruction of villages. For example, the agglomeration of villages has seen local governments merging rural villages, relocating residents to apartments, and selling land for revenue [212]. This agglomeration was first undertaken in the 1990s in southern coastal areas to stimulate urbanization (Han and Zhang 2012) and was later adopted by the Shandong Provincial Government for rural development [213,214].

Without enough allocated resources, "one size fits all" standards are often applied by the implementers to cope with the demands of higher authorities [201]. Large amounts of funding were directed to advertising and uniform urban features, like rebuilding streetlights and refurbishing bus stops, under the "Beautiful China" scheme [215]. In many regions, ethnic culture conservation has been simplified into redecorating buildings and residents' houses in a "minority" style [216–218]. For example, the Ximeng county government has reconstructed roofs and exterior walls since the early 2010s (Figure 7) but has not supported the beliefs and other cultural aspects of the Wa people (Figure 5) [219–221]. In addition to the Wa people, the cultures of other ethnic groups have been diminished, such as the Lahu, Yi, and Dai people in southwestern China [172,222,223].

4.2. Dilemma 2: Restricted Resources

Even if some local governments are willing to implement policies, they may lack the human, financial, technical, and organizational resources to implement them effectively.

As an example, the Guizhou province has introduced an e-commerce project involving nine townships and 106 villages; however, 13.73 million yuan of the poverty reduction fund is unused due to the lack of practical plans and insufficient e-commence skills [73]. Similar situations are reported in many other villages, which have failed to select suitable development initiatives [224].

Figure 7. Ximeng County reconstructed roofs and exterior walls with characteristics of the Wa people's culture (photo© authors).

In addition, expert support for investment is insufficient in many villages, so many poor decisions are made that have adverse impacts [57,225]. Hou and Lin [226] report failures that have occurred in some villages when implementing the plan. Rural communities' voices are often not taken seriously, and many useless projects have been funded. Local rural developments are often designed by urban companies who ignore the difference between urban (i.e., recreation) and rural (i.e., production) land functions. Some local governments have implemented ambitious plans but recognized that they were not feasible only after investing huge amounts of money [57,227,228]. In some villages, developments have removed common-pool resources collectively owned by all villagers, such as savings, pasture land, and forest [229]. Moreover, the pressure on officials implementing such a complex and ambitious policy may cause other unpredictable impacts. For example, China in 2014 set up "win-win" goals of adding more than 10 GW solar photovoltaic systems in poor rural areas by 2020 to eradicate rural poverty and transition to low-carbon energy [227,228]. However, this plan has not reduced poverty but instead has increased local corruption and accelerated land disputes in many regions due to poor planning and a lack of transparency and accountability [230–233]. In addition, most officials working on the ground to reduce poverty work excessive overtime, to the point that some officials have died since 2017 due to overwork [234]. The capacity to develop implementable plans at the local level is thus a major challenge.

To cope with limited natural and human resources, displacement and resettlement have been used by the Chinese government to more efficiently use infrastructure, public services, and human resources [235] and to achieve ambitious environmental goals [236] like carbon emission reduction, forest restoration, and watershed protection [230,237–239].

Although resettlement is an efficient approach to accomplish goals, resettlers commonly become impoverished after relocation and suffer from loss of land and homeland; unemployment; physical, social and psychological marginalization; disease; food insecurity; loss of common resources; and the disintegration of social structure [240,241]. In some poorly managed resettlements, impoverishment and disintegration of social structures have impacted not only the resettlers but also the broader population [236,242].

"Move out, resettle and get rich" (*bandechu, wendezhu, nengzhifu 搬得出, 稳得住, 能致富*) is a slogan widely used during the displacement and resettlement process, and it illustrates the core aim of improving resettlers' livelihoods [181]. However, the livelihoods (not to mention happiness and wealth) of many people who used to work as peasants are hard to recover after resettlement—even though they may be living in a new house—due to the loss of natural assets (like arable land and firewood from forests), lack of access to common property resources, and the loss of human assets (i.e., work-related knowledge and skills) [180,240,243]. Local environment protection actions in some areas, like Yunnan province, further diminish original income sources, like fishing, sand excavation, and gathering mountain products (e.g., herbs, mushrooms, and nuts), with little or no compensation in some cases [180].

4.3. Dilemma 3: Competing Narratives

Policies are interventions to influence management within a distributed system without encoding everyone's behavior or specifying every activity [244] and narrative in policies matters; these interventions can include guiding actions and the influencing of policy changes [245]. Competing narratives may disable policies or even cause a backlash against the original intention [244,246,247]. China's governance can be regarded as a distributed system with a central governing apparatus and subordinate local governance, as explicitly shown by its five-year plans [199,248,249]. Policy objectives, such as energy generation and carbon emission reduction, are adopted by the central government and then delegated to lower-tier authorities to implement [248,250]. Governing through a distributed system can help the Chinese central government achieve its targets, but yawning gaps between political intentions and actual outcomes are common [199,248,251,252].

We find some competing narratives in this plan, which have been downplayed. For example, the plan aims to manage mountains, water, forests, wetlands, grasslands, and agricultural lands holistically, but this strategy fails to consider a range of conflicts and trade-offs among these objectives [57,134,180]. For example, restoring grasslands and forests will be achieved by diminishing farming communities' access to agricultural lands [253,254]. Reducing desertification by planting trees will exacerbate water scarcity downstream [255–257]. In other cases, the plan may reinforce former and ongoing practices that have paid too much attention to targets and quotas, such as the number of relocated households and the size of enclosed grasslands and rangelands [181,231,258,259]. Rather than improving local communities' livelihoods and conserving water and forest or grasslands, reliance on binding environmental and social targets has triggered many undesirable practices. These include the use of unreliable data, corruption in local governments, and inadequate monitoring of implementation by lower levels of authority [199,246].

In addition, the industry upgrading and technological innovation favored in this policy rely on upgraded infrastructure, which may place greater pressure on the species and people affected [134,260]. For instance, rural tourism is now attracting capital to develop many rural villages. To entice more tourists, villages need to provide comfortable living and traveling conditions by constructing new infrastructure such as highways, bridges, boardwalks, and parks and by improving existing infrastructure such as roads, drainage systems, and telecommunication systems [69,261]. Although the principles in the plan emphasize that the process of rural development should be undertaken in a sustainable and environmentally friendly manner, limited measures have been adopted to manage potential negative environmental impacts. The development of new infrastructure, like roads (especially highways), dams, and irrigation systems, keeps posing high risks for the environment [56]. The Chinese government has set high standards, including ecological red lines. However, these policies have not successfully transformed on-ground practices due to coordination challenges among different departments and across regions [134,262–264].

The idea of ecological civilization seems to be a solution to this dilemma of competing narratives [134,265]. It is also an approach that meets national and international expectations. Yet it is hard to achieve because it assumes that rural communities' livelihoods and well-being will be enhanced after improving ecological conditions [180]. Many people's livelihoods and well-being will not be improved with environmental restoration but rather will be threatened due to loss of land, unemployment, and other impacts [134,180]. Furthermore, ecological civilization has been criticized as authoritarian environmentalism that sacrifices the interests of some groups to benefit vested interests and the broader society [182,185,187].

4.4. Policy Implications

Considering these shortcomings, this plan can be improved and better implemented. Here we propose three policy responses to cope with the dilemmas facing sustainable rural development in China (Q3).

4.4.1. Rural Community Voices Need to Be Taken More Seriously

Local governments would obtain benefit from respecting communities' voices and rights and involving Indigenous and local knowledge wherever possible [57,172,266]. While anticipating public demands, local agents need to design effective, locally adaptive policies, improve the efficiency of resource use, and avoid investing in unnecessary projects [227,230,231,267,268]. From our field experiences in villages, we found that most rural people have clear views about how to develop their rural industries, but their views are seldom considered by local policy implementers. As one interviewee, P(2), said, "I told them not to continue to distribute nuts seedlings and force us to plant them ... No one harvests them ... Nuts are not suitable for our location ... Nowadays, see the abundant water resources, ecological fish cultivation should be promoted ... They don't listen; gradually, I don't want to talk anymore ... ".

Failures to take rural communities' voices into account may be due to the ineffective design of the consultation system, which in most cases is via regular formal meetings in villages or among villages. One female villager, P(36), said, "I am afraid and don't want to speak at the meetings, whatever I say doesn't make any sense ... If I am speaking something scrambled, the leaders will be unhappy ... Everyone talks well at the meetings, but that's too boring. Gradually I don't even go to the meetings at all ... If they come to my home like you and sit with me and talk informally, I think I'd like to say more things". Although the importance of community voices is well recognised by the central government, the actual practices on the ground are still too formal and one-dimensional to gather and effectively evaluate multiple voices in a community [158,269,270]. We suggest that the central government may encourage local governments to design two-way, multiform and locally adaptive information gathering systems (e.g., internet forms, home visits, informal meetings) [271–273] to gather information from the voices of different groups of villagers; this may help to make locally adaptive policies to instruct rural development more easily and effectively [274–277]. If this is effective, then more local participatory planning initiatives and institutional interaction—e.g., with government oversight from higher levels (to ensure coordination and a lack of cumulative negative impacts)—could be piloted to empower rural residents and their rural development dreams [225].

4.4.2. Multiple Forms of Governance Need to Be Adopted Together

Despite institutional constraints, the Chinese central government has the capacity to effect changes in a complex policy environment; as an example, there are five levels of government (national, provincial, municipal, county level, and township level) and over twenty institutions at each level [246,248]. Therefore, more institutional interactions [225], including government reorganization or coalitions and government-business alliances [278], are needed to create or modify (e.g., simplify, combine, or compress) policy subsystems, thereby improving implementation effectiveness [65,279,280]. However, it will never be easy to innovate or challenge existing institutional arrangements or all those who prosper under the old order [281]. Establishing independent arbitration organizations or departments (e.g., the Hai He River Basin Commission) may be effective for carrying out specific large-scale and cross-boundary projects, which are generally mandated by the State Council, funded by large amounts of money and which concern many people; however, these cannot break existing boundaries in the administration systems (i.e., upper level vs. lower level), especially on universal social issues [200,281]. In addition, some existing governing practices, such as the rural revival in Hebei Province [106] and community market management in Beijing [282], provide good examples of working across boundaries in the current system. This bottom-up governance or participatory governance practice solves many long-lasting problems by entrusting communes with the power to "instruct" higher authorities to solve problems that cannot be solved by the original top-down system [106,158,280]. It can deal with unclear authority and overlapping institutions and further increase the transparency and accountability of the administration system [283]. However, how applicable this single case is to the rest of China is unknown [198].

4.4.3. Negative Impacts Need to Be Identified before Initiation

China has negatively impacted the environment through rapid economic development since the 1980s and is now aiming to accomplish "modernization" and "great rejuvenation" at a tremendous speed [133,284–286]. However, we argue that the development pace in some areas, like environmental protection and poverty alleviation, may be too fast to avoid or mitigate some of the negative impacts [180,278,287,288]. A villager, P(47), we interviewed said " ... the sudden and mandatory rigid environmental protection actions stop many construction projects, mining projects, and many other projects. However, these projects are the major sources of income for many rural residents, especially those who lost their land. Many people including me made a living as migrant workers ... Many horrible things happened in my village and a lot of other nearby villages, people were killed, robbed, raped ... The society is at risk and is backward. All these due to their income being not as stable as before".

Rural tourism has long been believed to be a catalyst for reviving rural areas and the local economy [288–290], and it is being adopted by almost all villages as a major approach to accomplishing sustainable rural development and alleviating poverty [229]. However, rural tourism is not a panacea for sustainably developing all rural areas, as thought by many local governments, because not all rural areas are attractive or potentially profitable enough as potential tourist attractions [287–289]. As Zheng [78] notes, in some villages, rural tourism starts rapidly but also decays swiftly because of a lack of new programs to attract tourists, inadequate infrastructure to support sustainability, and no proper regional planning and management processes [287]. In addition, many local governments in China have perceived rural tourism as a sightseeing development and paid little attention to the conservation and exploitation of heritage and Indigenous culture [78,291,292]. For example, in some traditional villages in Guizhou province, historic buildings are being demolished, making all residents' houses uniform and investing in unnecessary construction due to development without adequate consideration and planning [285,286].

Negative impacts as specified above are not identified, let alone mitigated, as there is no provision for strategic (environmental) impact assessments [293–295]. In contrast, the benefits brought by some rural development activities, such as rural tourism, have been exaggerated [287,296]. The State Council [297] has recognized this and initiated the Interim Regulations on Major Administrative Decision Process (IRMADP) to limit the negative impacts of administrative decisions; this legislation was effective from 1 September 2019. We therefore suggest that the Chinese government completes its strategic assessment system and accelerates its process to initiate impact assessments before making major decisions, especially on the policies that have broad and significant effects, like the plan.

4.5. Contributions, Limitations and Implications for Future Research

Although we have responded to the research questions, this paper cannot uncover all possible approaches to supporting sustainable rural development, all possible socio-political drivers and policy subsystems behind China's rural development strategy, and all possible challenges in implementing this strategy. Other perspectives may also bring different insights. For example, Schwab [5] proposes that we are now entering the Fourth Industrial Revolution, fundamentally changing the world we are living in through advanced technology [298]. Social innovation has been regarded by many scholars as an approach to develop or revive rural areas [299–302] and to support rural communities [303–305]. Will the rural development strategy proposed by the Chinese government be a milestone in social innovation [306]? Or will China's rural development strategy and the Fourth Industrial Revolution increase the power of the Internet of Things or digital transformation to make positive or negative social changes in a complex environment [307,308]? Or is the rural development strategy a further step towards digital authoritarianism with improved infrastructure [309–311]? These questions are relevant to the second research question but need further and more in-depth research to answer.

Despite the imperfect analysis, this paper makes three major contributions to the literature. First, we summarize two future scenarios and propose a new one of sustainable rural development. In short, China's rural strategy represents a new trajectory of sustainable rural development that engages rural and urban communities in a united structure (Figure 2), where they can have comparable infrastructure and public services and be equally attractive while representing different lifestyles. Second, we uncover the motivations of China to consolidate and extend its global leadership. In addition, we identify five socio-political drivers behind China's choice—food security, culture and heritage, overcapacity, environmental protection, and poverty eradication—of supporting rural areas by connecting this strategy with current social and economic issues. Third, we assess the feasibility of this strategy based on the latest publications and our fieldwork, summarize policy dilemmas, and provide three response options. Significantly, the arguments we made are not only based on the literature but also our fieldwork, providing detailed empirical evidence. Such extensive and multidisciplinary knowledge that is also synthesized has not been found in available publications. Lessons from the design and implementation of China's rural development strategy may benefit other countries or regions that aim to revive or develop rural areas. These three contributions open a window to scholars interested in rural, urban, and China studies and provide evidence for policymakers contemplating further reform.

If the Chinese Government can successfully address the dilemmas that we have identified, this may limit the negative impacts of rapid urbanization by 2050 rather than 2100. Chinese experiences in rural development can help to expand our assessment of rural and urban relationships beyond the two traditional scenarios summarized in this paper. Rural withering is a reality in many places around the world, raising the question of how to protect rural culture. Should we urbanize most people in "smart" cities and protect rural culture in museums by following the path of Scenario 1? Or should we revitalize and protect rural areas and culture in situ following the path of Scenario 2? Or should we start to think like the Chinese government and embed rural development in overall development plans? Future research could validate or evaluate our findings by developing broader comprehensive analysis such as regression analyses on overcapacity and rural infrastructure investment. More in-depth assessments of the implementation of China's rural policies could also provide invaluable experiences and lessons for supporting sustainable rural development around the world.

5. Conclusions

Inspired by China's latest rural development plan, this paper summarizes two future scenarios for developing rural areas and finds a new one for building resilience to pandemics, limiting the negative impacts of rapid urbanization, and developing rural areas sustainably; that is, reimagining development as a synergistic and dynamic process rather than a dualistic or tripartite structure.

The change in China from policy favoring urbanization to favoring rural development has surprised many scholars, and this paper uncovers China's domestic political objectives, namely food security, culture and heritage, overcapacity, environmental protection, and poverty eradication, which bolster its aspirations for global leadership.

To develop rural areas sustainably, China needs to effectively resolve three dilemmas: (1) implementing decentralized policies under central supervision; (2) deploying limited resources efficiently to achieve targets; and (3) addressing competing narratives in current policies. Involving more rural community voices, adopting multiple forms of local governance, and identifying and mitigating negative project impacts can be the starting points to manage these dilemmas. In addition, Chinese governments may still need detailed implementation plans to deal with the complexities and trade-offs in the governance of rural and urban, conservation and development, and monitoring and autonomy.

Supplementary Materials: The following are available online at https://www.mdpi.com/article/10.3390/land10050514/s1, Table S1: Interviewee list of the visited villages, and Table S2: Five aspects of China's rural development and 22 goals in the Strategic Plan of Rural Development (2018–2022).

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Credit Constraint, Interlinked Insurance and Credit Contract and Farmers' Adoption of Innovative Seeds-Field Experiment of the Loess Plateau

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Abstract: The interlinked insurance and credit contract is an emerging model of agricultural insurance in China. However, the development of interlinked insurance and credit contract and farmers' demands for it are poorly understood. Based on the wheat farmers on the Loess Plateau in China, a field experiment is employed to obtain dynamic choice data from 415 farmers. We empirically analyzed the inhibitory effect of credit constraint on farmers' adoption behavior of innovative seeds and also explored the heterogeneity of farmers' innovative seeds adoption due to the availability of interlinked insurance and credit contract. The results illustrate that credit constraint can hinder farmers' innovative seeds adoption significantly, and interlinked insurance and credit contracts can encourage farmers to adopt innovative seeds effectively by dispersing natural risks and alleviating credit rationing. Further, constrained by low education levels in China's rural areas, providing interlinked insurance and credit contract to farmers is not beneficial to enhance farmers' innovative seeds adoption. In addition, farmers who are relatively poor may underestimate the benefits of innovative seeds at the beginning of planting, making their adoption behavior have some delayed effect. This research provides a new perspective for promoting the spread of innovative technology in rural areas.

Keywords: credit constraint; interlinked insurance and credit contract; technological adoption; innovative seeds; field experiment

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1. Introduction

Climate change triggers the frequency and severity of natural disasters [1], which in turn will harm the agricultural sector and exacerbate the food crisis. A report jointly released in 2020 by the Food and Agriculture Organization of the United Nations, the International Fund for Agricultural Development, the World Food Program, and other agencies shows that 690 million people worldwide will go hungry as the new crown pneumonia epidemic, extreme weather, rising international energy prices, and geopolitical conflicts overlap. There is an obvious trend that the world is on the verge of the most serious food crisis in at least 50 years, and food crises will be more pronounced in developing countries, which are less resilient to natural disasters [2]. Therefore, improving farmers' resilience to disasters, promoting sustainable agricultural development, and coping with the global environment of uncertainty have become urgent issues worldwide.

Given the complex and diverse geographical and climatic conditions as well as the high risk and frequency of natural disasters, China's agricultural production is exposed to greater systemic risks [3,4]. According to China's 2020 National Economic and Social Development Statistical Bulletin, in 2020, China suffered the largest flood since

1998, resulting in a crop damage area of 19,957.7 thousand hectares, of which 2706.1 thousand hectares were extinguished, with a direct economic loss of CNY 370.15 billion. Moreover, rural households are characterized by insufficient resources and a high degree of concurrent industrialization, which hinders farmers' investments in productivity-enhancing technology [3,5]. Constrained by the long agricultural production cycles and lack of risk management tools [6], the agricultural industry's huge production losses are always difficult to disperse when natural disasters occur, which easily results in falling into the poverty trap [7]. Growing evidence indicates that the adoption of innovative agricultural technology is an important means for farmers to resist natural risks, increase farm income, and stabilize agricultural production [8–10], which is helpful in improving agricultural production efficiency, ensuring food security, and alleviating rural poverty [11–13].

China's agricultural science and technology have developed rapidly. After ten years of development, the contribution rate of agricultural science and technology progress exceeds 61%, which is an increase of 7% ("The 13th Five-Year Plan" China Agricultural and Rural Science and Technology Development Report). Among them, seeds are the most basic and important investment for agricultural production and an important carrier of agricultural science and technology [14]. Seed innovation is important for increasing agricultural production and income and ensuring national and even global food security. Since the enactment of the seed law in 2000, China has gradually embarked on an independent and comprehensive path of seed industry development. At present, China's superior seed coverage rate exceeds 96%, contributing to more than 45% of grain production. However, foreign dependence on crop seeds remains high. According to the Chinese Seed Industry Development Report 2021, China's seed trade deficit was as high as USD 230 million in 2019, and there is still a large gap between the seed industry's independent innovation and that of developed countries. However, farmers usually encounter the dualistic economic structure [15], risk allocation, and price allocation in China [16,17]. Due to credit constraints, farmers' adoption of new agricultural technology is severely inhibited [11,16–18], which further hinders the improvement of income and welfare levels [19,20]. It is obvious that for developing countries such as China, there is a long way to go to accelerate the development of the modern seed industry.

In this circumstance, purchasing agricultural insurance became an efficient way to resist agricultural risks and economic losses [21–24]. Existing studies suggest that agricultural insurance supports farmers' technology investment activities in two main ways: on the one hand, by increasing farmers' risk tolerance and thereby changing their risk coping strategies [6,25]. On the other hand, by alleviating farmers' financial constraints to boost their agricultural investment [26,27]. The Chinese government has attached great importance to the promotion and improvement of agricultural insurance since 2004. What is of great concern is that the keyword "insurance" is mentioned 11 times in the No. 1 document of the Central Government in 2022. Agricultural insurance in China has come a long way in nearly 20 years, yet the effectiveness of agricultural insurance in promoting farmers' adoption of innovative agricultural technology is not satisfactory [28,29]. Furthermore, the insurance companies lack the incentive to innovate and update targeted insurance products, which stems from the policy-based agricultural insurance system. As it continues to evolve, such a system gradually highlights institutional weaknesses (e.g., adverse selection, moral hazard, over-reliance on government subsidies, etc.) [30]. Moreover, due to the asymmetry of information and lack of trust, the demand for and acceptance of agricultural insurance are still low in China [31].

Therefore, more and more studies emphasize that interlinked insurance and credit contract is a valuable tool that can address chronic poverty caused by insurance and credit market failures in low-income countries efficiently [11]. This is because, compared to traditional agricultural insurance, the linkage between insurance and credit markets can alleviate financial constraints on farmers effectively, transfer agricultural systemic risks, and promote farmers' adoption behaviors of agricultural technology [32,33]. Moreover, a large body of studies shows that interlinked insurance and credit contracts can transfer agricultural production risks, reduce the lending risks of financial institutions, expand farmers' demand for credit, and weaken the risks arising from farmers' self-selection. In other words, the contract is a "stabilizer" that can facilitate the effective adoption of innovative technology by farmers [34–36]. However, some scholars hold the opposite view and argue that interlinked insurance and credit contract do not promote farmers' adoption of innovative technology. Farmers who purchase only an insurance contract are more receptive to technology use than farmers who purchase an interlinked insurance and credit contract. This can be explained in terms of the cost of loan defaults, where smaller default penalties motivate farmers to adopt higher levels of technology [19,37]. At the same time, farmers' agricultural technology adoption behaviors are heterogeneous due to different social environments, cultural backgrounds, and agricultural patterns. In addition, factors such as model differences, type of technology, and within-sample variability can also make farmers' technology adoption behavior variable [38,39].

In light of the preceding analysis, the aim of this paper is to verify the inhibitory effect of credit constraints on farmers' adoption of innovative seed technology through data obtained from a field experiment. Then we examine farmers' willingness to adopt innovative seeds in the presence or absence of interlinked insurance and credit contract. This study specifically addresses the adoption of traditional and innovative wheat seeds among wheat farmers in the Shaanxi and Shanxi provinces of China. The following three points summarize this paper's marginal contributions: First, we examine the moderating effect of credit constraint on the inhibition of farmers' adoption of innovative seeds, given the mechanism by which interlinked insurance and credit contract promote farmers' adoption of innovative seeds. Second, we analyze the impediments to the demand for interlinked insurance and credit contract in the current stage of China's agricultural development, which provide a theoretical reference for the further development of interlinked insurance and credit contract. Third, we simulate the real situation with a field experiment, allowing farmers to make dynamic choices based on their understanding of the operation mechanism of interlinked insurance and credit contract, overcoming the disadvantage that questionnaire surveys can only obtain static time-point indicators.

The rest of the paper is structured as follows: Section 2 is theoretical analysis, Section 3 focuses on sample selection and field economics experimental design, Section 4 is empirical analysis, Section 5 is the discussion, and Section 6 concludes the full paper and makes policy recommendations.

2. Theoretical Analysis

2.1. Credit Constraint and Farmers' Adoption of Innovative Seeds

The early theories of credit availability and credit rationing laid the foundation for the development of credit constraint theory. The role of credit constraints in discouraging farmers from investing in innovative technology is widely recognized by academics. For example, Carter and Olinto [40,41] indicate that farmers with liquidity constraints will invest less when the credit supply is inadequate. Shiferaw et al. [42] also provided empirical support for the finding that credit constraint hinders farmers' adoption of innovative agricultural technology. Tesfaye et al. [43] concluded that smallholder farmers tend to operate below the production possibility frontier because of financing constraints that prevent them from adopting more efficient and labor-saving irrigation technology. Therefore, improving smallholder farmers' access to credit is necessary. However, with the gradual advancement of research, more and more researchers find that in addition to credit, constraints arise from credit rationing, farmers' own risk aversion, and cognitive biases also contribute to credit constraint [44,45].

For supply-based credit constraints, financial institutions in rural areas are constrained by high business costs and risks, as well as information mismatches, and engage in interest rate regulation to reduce credit supply and implement credit rationing on a property basis. Then, it is difficult to satisfy farmers' loan requirements, and agricultural technology with high investment is restricted. On the other hand, farmers, as the main demanders of credit, may encounter credit repression or credit substitution due to risk aversion and cognitive preferences. Therefore, farmers' motivation to take out loans may be reduced because of the fear that the credit amount will not satisfy their needs or the fear of losing collateral [46–48], and the adoption of agricultural technology will be limited as a result. Therefore, we propose hypothesis 1 in this paper.

Hypothesis 1. *Credit constraint inhibits farmers' adoption of innovative seeds.*

2.2. Interlinked Insurance and Credit Contract and Farmers' Adoption of Innovative Seeds

Most of the existing literature has concluded that insurance can produce the same effect as credit collateral to a certain extent by spreading the farmer's credit risk [21,49]. The "interlinked insurance and credit contract" approach not only helps credit institutions transfer their own lending risks but also helps farmers obtain the financial credit support needed for the development of agriculture [32,49,50], thus encouraging farmers to adopt innovative technology [37,51]. Rural financial institutions in China serve more small-scale farmers, who have a dispersed spatial distribution and significant information asymmetry issues [23]. Interlinked insurance and credit contract provides insurance for farmers, which can help them solve the problem of insufficient credit effectively. It can also definitely reduce the moral hazard problem in the contract performance process. Therefore, we believe that the cooperative approach of interlinked insurance and credit contract can alleviate farmers' credit constraints effectively and promote their adoption of innovative technology. Therefore, we propose hypothesis 2 in this paper.

Hypothesis 2. *Interlinked insurance and credit contract can promote farmers' adoption behavior of innovative seeds effectively.*

2.3. Moderating Effects of Interlinked Insurance and Credit Contract

The credit and insurance interconnection paradigm was formally proposed in China in the 2009 Central Government Document No. 1, which stated that interlinked insurance and credit contract is one of the most important measures for dispersing agricultural risks [10,12,45,52]. The easing of credit constraints provides not only financial support for farmers' investments in innovative seeds but also supplies large amounts of capital inputs in agricultural production for farmers. A number of papers indicate that due to the risk dispersion of interlinked insurance and credit contract, credit institutions are always willing to enlarge the credit amount to farmers [19,53]. Therefore, it is acknowledged that the impact of credit constraints on farmers' adoption behavior of innovative seed technology may considerably depend on the participation of interlinked insurance and credit contract products. That is, if farmers choose to purchase the interlinked insurance and credit contract, their constraint on risk and credit will be alleviated, and moral hazard in the process of financial contract performance will be reduced. Therefore, we propose hypothesis 3 (Figure 1) in this paper.

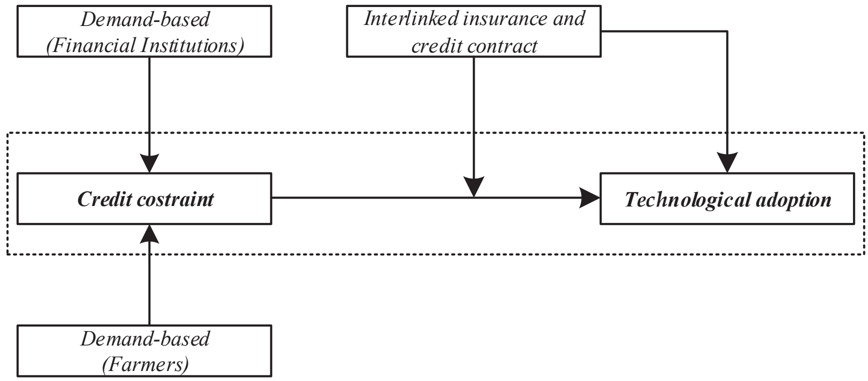

Figure 1. Mechanism analysis.

Hypothesis 3. *The interlinked insurance and credit contract can alleviate the inhibitory effect of credit constraint on the framers' adoption of innovative seeds effectively.*

3. Experiment Design

3.1. Experiment Set and Distribution of Samples

The data used in this study come from the survey and field experiment that we implemented in July and August of 2021 (Appendix C). By using the multi-stage stratified sampling method, we selected a total of 415 wheat farmers in the Shaanxi and Shanxi provinces of China as sample farmers (Figure 2). We first selected the sample wheat farmers from four counties randomly. In Shaanxi Province, this includes Heyang and Yongshou counties, while in Shanxi Province, it includes Yaodu and Pinglu counties. Second, considering the level of economic development and geographical location, five towns were selected in each sampling county (Table 1). Finally, we obtained the list of villagers from the local village committees and selected the sampling farmers according to the principles of 2, 4, and 10 distances for villages with less than 50, 51–100, and more than 100 households, respectively. Figure 3 illustrates the sampling procedure.

The principles of area selection are based on two aspects:

The first is crop cultivation systems. Wheat is the main food crop in the Loess Plateau region of China, where agricultural production conditions and climatic conditions vary greatly. In China, the wheat cultivation system is complex, with three categories: winter wheat once a year, two-crop winter wheat and summer corn once a year, and three-crop winter wheat and summer corn (other grains)—spring corn twice a year. In our study areas, Yongshou County is a one-crop winter wheat planting area; Heyang County and Yaodu District are one-crop and two-crop planting areas; and Pinglu County is a mixture of two-crop a year and three-crop twice a year. The above areas are important wheat-producing areas in northern China. It is of great significance to study the adoption of new wheat technology in these areas to guarantee national food security.

Second, the degree of technological development in wheat cultivation. Shanxi Province and north-central Shaanxi Province in China are part of the Loess Plateau region. Due to low precipitation and dry weather, soil erosion and loss of fertility in these areas are severe, threatening the quality of wheat agricultural development and sustainable agricultural development in these regions. Heyang and Yongshou counties in Shaanxi Province are identified as dryland wheat integration trial areas by the Department of Agriculture and Rural Affairs of Shaanxi Province in the 2017 Shaanxi Wheat Trial Implementation Plan. Additionally, Heyang County in Shaanxi Province was listed as a national agricultural science and technology modernization pioneer county in 2021 by the Ministry of Agriculture and Rural Affairs of the People's Republic of China. To encourage the introduction of science and technology into rural areas, Shaanxi Province introduced the "Agricultural

Technology Promotion Achievement Award". Pinglu County in Shanxi Province built 16,000 mu of organic wheat dry farming and water-saving agriculture demonstration park in 2019 and formulated the "Implementation Plan for the Construction of Organic Dry Farming Organic Wheat Demonstration Area in Pinglu County" to guide the sowing of good varieties and improve the quality of wheat. Moreover, based on the 14th Five-Year Plan, Yao Du District launched the organic dry farming wheat cultivation advice in 2021, which provides detailed guidance on dryland wheat technology selection and variety selection to further demonstrate the effectiveness of organic dry farming development.

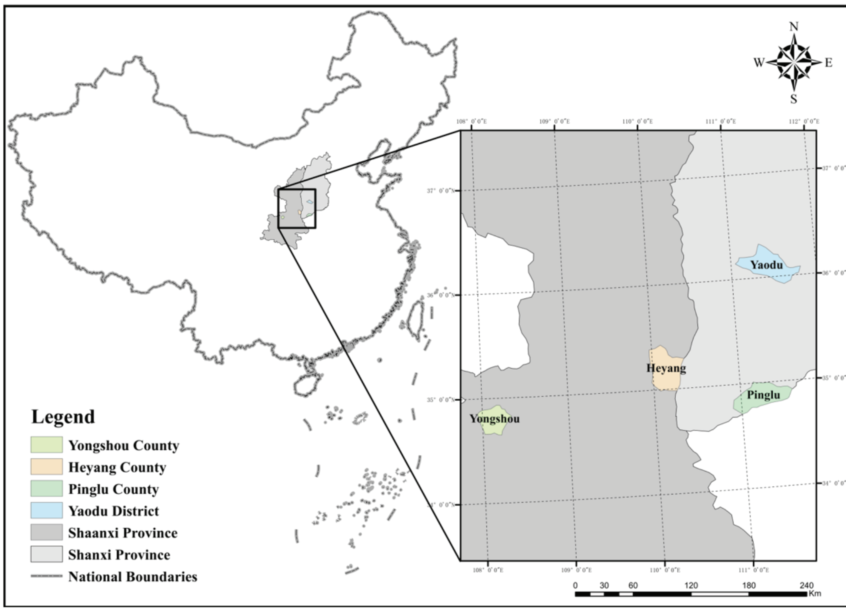

Figure 2. Sample locations.

Table 1. Sample distribution.

Province	Sample Cities (Counties)	Sample Cities (Counties)	Number of Samples	Percentage
Shaanxi Province	Yongshou County	Changning Town, Ganjing Town, Quzi Town, Dian Tou Town, Jianjun Town	79	19.04%
	Heyang County	Wangcun Town, Lujing Town, Heichi Town, Xinchi Town, Fang Town	178	42.89%
Shanxi Province	Yaodu District	Jindian Town, Tumen Town, Qiaoli Town, Wucun Town, Xiandi Town	75	18.07%
	Pinglu County	Shengrenjian Town, Zhangdian Town, Sanmen Town, Changle Town, Podi Town	83	20.00%

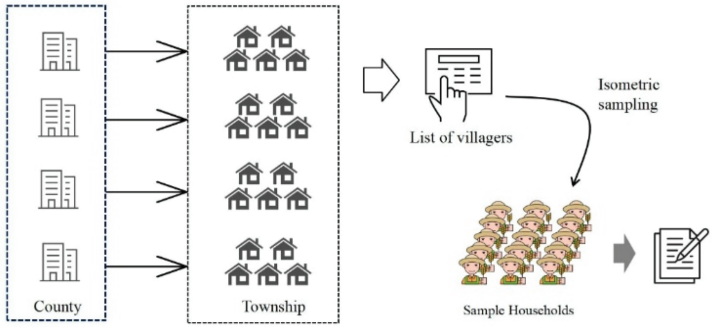

Figure 3. Illustration of stratified sampling.

Therefore, it is believed that the above sites can represent farmers' adoption behavior of innovative seeds in the Loess Plateau region of China.

3.2. Experimental Design

3.2.1. Research Methodology

Both theory and practice show that the interlinked insurance and credit contract has grown in China in recent years, but their further development is hampered by small-scale and regional heterogeneity. Based on the survey, we learned that the type of crop seeds is the most important factor affecting the yield, and farmers also attach great importance to crop seed varieties. As a result, we selected innovative seeds to represent new technology.

It is well known that agricultural production is continuous and farmers' technology selection behavior is dynamic, so it would be difficult to examine the impact of interlinked insurance and credit contract on farmers' adoption of innovative seeds through a traditional questionnaire survey. Consequently, in order to reduce survey bias and ensure a more accurate estimation of results, a field experiment was adopted to collect data concerning farmers' preferences for interlinked insurance and credit contract and innovative seeds adoption [54]. Firstly, we selected a sample of subjects from an overall population randomly and divided them into a control group and a treatment group; the sample from the treatment group was treated experimentally. Since subjects are randomly divided into two groups, the treatment group is completely independent of individual characteristics and other factors that might affect the experimental results, which avoids the problem of omitted variable bias or endogenous variable bias commonly [55], so the experimental process of the field experiment is close to the real world and could make tests of causal relationships between variables more direct and convenient.

3.2.2. Research Methodology

1. **The setting of groups.** (1) Control group. Farmers in this group choose between traditional wheat seeds that do not require credit and innovative wheat seeds that do; (2) Treatment group. Farmers in this group make decisions between traditional wheat seeds that are not financially constrained and innovative wheat seeds that provide interlinked insurance and credit contract.
2. **The setting of production conditions.** Referring to the study of Tang et al. [6], we assume that the farmers owe CNY 4200 in terms of capital and 10 Mu cultivated land at the beginning. In the first year, farmers are required to make a choice of wheat seeds between No. 0 seeds and No. 1 seeds. The differences in seeds, production inputs, and income under different weather conditions for these two kinds of seeds are shown in Table 2. If farmers choose No. 0 seeds, their own capital is enough to satisfy the demand for production; if they choose No. 1 seeds, farmers need to apply for a loan of CNY 1800 and submit collateral worth CNY 1800 (we assume the farmers can afford it). At the end of the year, if the weather is suitable for wheat growth, the farmers

who planted No. 1 seeds will obtain the collateral back after repaying the loan; if the weather is bad, the farmers planting No. 1 seeds are unable to repay the loan, and the bank will confiscate the collateral, so farmers will lose CNY 1800. Farmers who do not go bankrupt in the first round of experiments will continue with the second round of experiments, and the final payoff in this experiment will be determined by the remaining funds in each farmer's hand at the end of the last year.

3. **The setting of weather conditions.** Considering that the weather conditions in the previous year may affect planting plans for the next year, we simplify the weather conditions in the areas into two categories: disaster (bad weather) and normal (good weather). Farmers randomly draw a card from the black box containing four red cards and two black cards; the black card represents bad weather, while the red card represents good weather. According to the local meteorological information, we can know that the incidence of disaster weather is one-third. Farmers are required to determine the natural conditions they face by drawing cards randomly, ensuring that they do not know the weather conditions of the year. Moreover, the loss will be 1.55 times higher than that of normal seeds if bad weather occurs. The main parameters are presented in Table 2.

Table 2. Experimental parameter settings comparison of traditional and innovative seeds.

Experimental Group	Seed Variety	Production Input	Loan	Premium	Planting Income (Good)	Balance (Good)	Planting Income (Bad)	Balance (Bad)
Control group	No. 0 seeds	4000	0	0	7000	7200	0	200
	No. 1 seeds	6000	1800	0	12,000	10,200	0	−1800
Treatment group	No. 0 seeds	4000	0	0	7000	7200	0	200
	No. 1 seeds	6000	2000	200	12000	10,000	0	0

4 **The experimental process (Appendix B).** Before the experiment, we explained to farmers, in text (the experimental instruction manual), the details of the experimental situation, the main parameter, the task arrangements of the experiment, and the relevant requirements. Additionally, the tester continued to demonstrate the experimental process until the farmers fully understand the entire experimental content. To avoid communications between farmers, four farmers were taken by each tester and separated by baffles to ensure the independence of choice. If farmers in the control group choose No. 0 seeds, their own capital is enough to maintain agricultural production. If the weather is suitable for planting (good weather), they earn CNY 7000 and have a balance of CNY 7200. If the weather is not suitable (bad weather), they have no income and a balance of CNY 200. If farmers choose No. 1 seeds, they need to apply for a credit of CNY 1800. Moreover, they are required to provide the banks with equally valued collateral. At the end of the year, they receive the collateral back and obtain a balance of CNY 10,200 if the weather is good. However, if bad weather occurs, farmers who choose No. 1 seeds lose the collateral worth CNY 1800. The loss to farmers is CNY 1800. Since farmers experiencing bad weather in the first year would fall into bankruptcy, we added an exit option in the second year (i.e., withdrawing from agricultural production). The experiment was conducted one more time while other scenarios were the same as in the first year.

In the treatment group, a game was implemented to help farmers in the experimental group understand the difference between a traditional insurance contract and an interlinked insurance and credit contract. Next, the farmers were asked to answer some simple test questions to see if they fully understood the contract. If the farmer still did not understand the experiment, the tester explained it in greater detail until they did. In terms of the treatment group, the basic conditions are the same as those in the control group, and the only difference is that the farmers who chose No. 1

seeds were required to purchase an interlinked insurance and credit contract with a premium of CNY 200. Therefore, farmers needed to borrow CNY 2000 from the bank and also provided collateral of CNY 2000. At that point, if the weather was suitable for planting (good weather), they received a satisfactory output. However, if bad weather occurs, the insurance company pays the bank first, and the farmers receive the collateral back. They will have no income and a balance of CNY 0.

5 **The measurement of farmers' risk attitude.** Risk attitude is a major force influencing farmers' decisions and an important factor in the adoption of innovative seeds by farmers due to credit constraints and interlinked insurance and credit contracts [32,56]. In order to obtain accurate information concerning farmers' risk attitudes, we measured farmers' risk attitudes through a field experiment. First, farmers were informed that there are three black cards and three red cards in a transparent bag, and the rewards for drawing the black and red cards are shown in Table 3. Then, farmers are required to make their choices. Only the farmers who chose Plan B1 proceeded with the game, as it could help us improve the accuracy of formal experiments and reduce invalid samples.

Table 3. Test Games.

Risk Options	Plan A1		Plan B1	
	Red card	Black card	Red card	Black card
	15	20	16	21

Ten sets of formal tests were set up (see Table 4), each of which includes both low-risk and high-risk reward options. Farmers select either reward Plan A2 or B2 from each set, of which Plan A2 implies low risk while Plan B2 implies high risk. In the experiment, we established two premises: first, farmers were explicitly informed that there were three black cards and three red cards in the bag. Second, there are six cards in total, but the colors are unknown to farmers. The two settings above are used to measure the risk attitude indices with definite probability and ambiguous probability, respectively, according to the farmers' choice (Equations (1) and (2)).

$$Risk_d = \frac{N - B2_{nd}}{N} \tag{1}$$

$$Risk_d = \frac{N - B2_{nd}}{N} \tag{2}$$

where $Risk_d$ and $Risk_f$ indicate the risk level under definite probability and the risk level under ambiguous probability, respectively; N is the total number of experiments; $B2_{nd}$ is the number of times that who chose reward Plan B2 with definite probability, while $B2_{nf}$ is the number of times that who choice reward Plan B2 with ambiguous probability. The risk attitude level has a value range of [0,1], where 1 indicates that the farmer is extremely risk averse and 0 indicates that the farmer extremely prefers risks.

Individual characteristics of the household head, family characteristics, participation in technological training, and other external information are obtained from the questionnaire (Appendix A). The whole experiment lasts about 80 min, and the farmers will be paid accordingly (around CNY 60, which is equal to 1/1000 of the annual budget in the experiment) when they complete the experiment.

Table 4. Experimental protocol.

Options	Plan A2		Plan B2	
	Red Card	**Black Card**	**Red Card**	**Black Card**
1	20	20	22	18
2	20	20	23	17
3	20	20	25	15
4	20	20	35	15
5	20	20	37	13
6	20	20	40	10
7	20	20	52	8
8	20	20	54	6
9	20	20	56	4
10	20	20	60	0

3.3. Control Variables

3.3.1. Selection of Control Variables

In order to avoid the impact of other factors on the results, we control the characteristics of the household head, the characteristics of the household, and the support of the government [43,57].

3.3.2. Descriptive Statistics of the Variables

The definitions and descriptive statistics of variables are shown in Table 5. The average age of the farmers is 56.93 years, and the average years of education are 7.51 years; most of the farmers have not completed junior high school or higher education ($\geq$9 years). In terms of the change from wheat cultivation area to cropland area, the proportion is 68% on average, and wheat is the main crop in the sample area, which is also in line with the field experiment. The distance of farmers from the nearest financial institutions, such as rural credit institutions, is 5.3 miles on average, which may affect relevant services, information transmission, etc. In the past three years, the average number of times farmers attended training on wheat growing techniques is less than 1, which indicates the low willingness of farmers to participate in agricultural technology training.

3.4. Model Setting

According to the field experiment, the dependent variable in the first round is the binary choice between innovative wheat seeds and traditional wheat seeds. In order to test the effect of credit constraint on the framer's adoption of innovative seeds, we first constructed a binary *Probit* model as follows:

$$Probit(Choice = 1|Credit, x) = \varphi(Credit\beta + x\theta) \tag{3}$$

where *Choice* indicates the farmer's choice of wheat seeds; if the farmer chooses innovative wheat seeds, *Choice* = 1; otherwise, we assigned the value of 0. *Credit* indicates credit constraint, which is used to examine the effect of credit constraint on a farmer's adoption behavior of innovative wheat seeds, we assigned the value of 1 if the farmer belonged to the treatment group; otherwise, we assigned the value of 0. x is the vector of control variables; β and θ are regression coefficient estimates; and $\varphi(\cdot)$ is a normally distributed probability function.

Table 5. Variable definition and descriptive statistics.

Variables	Meaning and Assignment of Variables	Mean	S.D.
Choice	Choice1: The technology selection in the first round of experimentTraditional seeds = 0, Innovative seeds = 1	0.52	0.50
	Choice2: The technology selection in the second round of experimentTraditional seeds = 0, innovative seeds = 1	0.54	0.49
Credit constraint	If CNY 50,000 is needed for production turnaround, how easy is it to borrow? (1 = very difficult; 2 = a little bit difficulty; 3 = okay; 4 = easy; 5 = very easy)	3.43	1.22
Interlinked insurance and credit contract	If the farmer belongs to treatment group, then assign thevalue of 1; otherwise, then assigned 0	0.46	0.49
Age	The actual age of the respondent, Unit: year	56.93	9.49
Education	Years of education of respondent, Unit: year	7.51	2.89
Leader	Is the head of the household a village official?1 = Yes; 0 = No	0.16	0.36
Income	Total income of the sample households in the last year., unit: Yuan	1.42	5.53
Number	Number of plots planted with wheat, Unit: block	4.44	29.38
Labor	Number of family agricultural laborers	2.05	0.90
Ratio	Ratio of wheat cultivation area to cultivated area (%)	0.68	0.29
Financial	Are there any family members or relatives working in financial institutions? 1 = Yes; 0 = No	0.04	0.19
Insurance	Did your household take out insurance for growing wheat last year? (1 = yes; 0 = no)	0.51	0.50
Risk	Measured by the Farmers' Risk Attitude Test	0.32	0.35
Training	Number of times respondents attended training on wheat growing techniques in the past year	0.69	2.42
Information	Does the village provide technological information services for defense against weather hazards? 1 = Yes; 0 = No	0.52	0.50
Distance	How far is your home from the nearest financial institution, such as a rural credit union? Unit: mile	5.30	3.73
Perception	How do you think the local precipitation in the last 5 years? 1 = significantly decreased; 2 = somewhat decreased; 3 = not significantly changed; 4 = somewhat increased; 5 = significantly increased	2.81	0.93
Climate	Do you think the local climate has been warming in the last 30 years? 1 = very disagree; 2 = disagree; 3 = neutral; 4 = agree; 5 = very agree	4.23	0.88
Province	0 = Shanxi, 1 = Shanxi	0.62	0.49

According to the design of the field experiment, farmers who chose innovative wheat seeds in the first round of the experiment with bad weather dropped out of farm production due to bankruptcy, so their choice in the second round of the experiment became multiple choices. Therefore, we further examined the effect of credit constraint on farmers' adoption of innovative wheat seeds using the *MultipleProbit* model, which is set up as follows:

$$Probit(choice = j \mid x_i) = Probit\{\varepsilon_{ik} - \varepsilon_{ij} \leq (x_{ij}\text{-}x_{ij})\ \beta\} \tag{4}$$

where *Choice* indicates the farmer's choice of wheat seeds; if the farmer chooses innovative wheat seeds, *Choice* = 1; otherwise, we assign the value of 0. Both j and k indicates the farmer's technology choice options and x_i is the explanatory variable.

4. Empirical Results

4.1. Baseline Regression

4.1.1. First-Round Experimental Regression Results

Table 6 (the first two columns) reports the effects of credit constraints on farmers' adoption of innovative seeds in the first round of experiments. The regression model indicates that credit constraint has a significantly negative impact on farmers' innovative seeds choices at the level of 1%, which is consistent with the finding of Tesfaye et al. [43]. Hypothesis 1 proposed in this paper was tested; that is, credit constraint inhibits farmers' adoption of innovative seeds. Moreover, from the marginal effect regression results, we can see that the coefficient of credit constraint is −0.1932, which implies that when credit constraint increases by 1 unit, the probability of adopting innovative seeds by farmers will decrease by 19%. Concurrently, interlinked insurance and credit contract has a significant positive effect on farmers' adoption of innovative seeds, and its coefficient is significantly positive at the level of 5%, implying that interlinked insurance and credit contract can promote farmers' adoption of innovative seeds, and Hypothesis 2 proposed in this paper is verified. According to the marginal effect regression results, for each 1% increase in the probability that a farmer purchases interlinked insurance and credit contracts, the probability that a farmer adopts innovative seeds will increase by 0.23%. This is consistent with the findings of Carter et al. [51] and Farrin et al. [37]. On the one hand, interlinked insurance and credit contracts can reduce farmers' credit rationing and address financial constraints. On the other hand, it makes farmers' technology investment risks to be mitigated.

Besides the effect of credit constraint and the "interlinked insurance and credit contract", the results in Table 6 reveal that among the individual factors, both years of education and the variable of leader have a positive effect on the farmers' adoption of innovative seeds at the level of 10% significantly, which indicates that the higher the education level, the better the farmer's understanding and ability to understand new technology [10]. As we learned in the questionnaire research, farmers who are village cadres have more opportunities to participate in relevant training and have more resources than ordinary villagers, which results in a more positive attitude toward the adoption of innovative seeds. Among the household factors, the coefficient of household income is significantly positive, indicating that the higher the household income, the more it can promote the farmers' adoption of innovative seeds. Household income is an important indicator of production and living conditions, and farmers with high levels of household income tend to have higher levels of part-time employment. At the same time, farming has higher opportunity costs [50]. Due to the high risk and cost of innovative seeds inputs, well-financed households not only have a higher willingness to replace traditional seeds with innovative seeds but also have the ability to afford the higher costs of innovative technology. The variable of risk preference is significantly positive at the level of 5%, which indicates that farmers with a stronger risk preference are more likely to be inclined to adopt high-risk, high-reward innovative seeds. This is in line with the study of Giné et al. [58], which concluded that the stronger the risk perception of individuals, the more inclined they are to take measures such as purchasing insurance to avoid risk, and they are more concerned with benefits than risks and therefore prefer new technology with high risks and high rewards [6]. In general, farmers who participate in technology training have a higher level of knowledge about innovative seeds and awareness of the economic benefits. They can learn more about the potential of the adopted seeds, thus reducing the risks and uncertainties associated with technology for farmers and promoting the adoption of innovative seed technology. However, the regression results show that "How many times have you attended training on wheat growing technologies in the last year?" is significantly negative, which is not consistent with expectations. We learned in our field experiment that most farmers may not be able to properly assess the potential impact of technology training and that they participate in training less than once on average. "Does the village provide technological information services for defending against meteorological disasters?" is significantly positive at the level of 5%, indicating that meteorological information services can alleviate information asymmetry and thus promote farmers' adoption of innovative seeds. Among the regional variables, "Distance to the nearest financial institution" has a significant negative effect on the farmers' adoption of innovative seeds. The closer the distance is to the financial institution, the lower the cost of information and time for farmers to obtain relevant credit policies, which is more conducive to farmers' innovative seeds adoption behavior [59,60].

Table 6. Regression results of probit model for two rounds of experiments.

Variables	First Round of Experiments		Second Round of Experiments	
	Probit Model	**Marginal Effect**	**Probit Model**	**Marginal Effect**
Credit constraint	−0.4851 *** (0.07)	−0.1932 *** (0.02)	−0.6038 *** (0.08)	−0.2317 *** (0.03)
Interlinked insurance and credit contract	0.6047 ** (0.15)	0.2369 *** (0.06)	0.5841 ** (0.16)	0.2197 ** (0.06)
Age	−0.0015 (0.00)	−0.0005 (0.00)	−0.0106 (0.01)	−0.0041 (0.00)
Education	0.0434 * (0.03)	0.0173 * (0.01)	0.0487 * (0.03)	0.0187 * (0.01)
Leader	0.3557 * (0.21)	0.1391 * (0.08)	0.1707 (0.22)	0.0642 (0.08)
Income	0.1392 ** (0.07)	0.0555 ** (0.03)	0.3721 ** (0.11)	0.1427 *** (0.04)
Number	−0.0369 (0.02)	−0.0147 (0.01)	−0.0328 (0.03)	−0.0126 (0.01)
Labor	−0.0363 (0.08)	−0.0145 (0.03)	0.0350 (0.08)	0.0134 (0.03)
Ratio	0.4595 * (0.25)	0.1831 * (0.10)	0.3541 (0.26)	0.1358 (0.10)
Financial	−0.4997 (0.39)	−0.1942 (0.14)	−0.6386 * (0.39)	−0.2505 * (0.15)
Insurance	−0.0115 (0.16)	−0.0046 (0.07)	0.0277 (0.17)	0.0106 (0.07)
Risk	0.5456 ** (0.20)	0.2174 ** (0.08)	0.4929 ** (0.21)	0.1890 ** (0.08)
Training	−0.1307 ** (0.05)	−0.0521 ** (0.02)	−0.0474 (0.04)	−0.0182 (0.02)
Information	0.4575 ** (0.16)	0.1808 ** (0.06)	0.3464 ** (0.17)	0.1325 ** (0.06)
Distance	−0.0466 ** (0.02)	−0.0186 ** (0.01)	−0.0334 (0.02)	−0.0128 (0.01)
Perception	0.0055 (0.08)	−0.0048 (0.03)	−0.1308 * (0.08)	−0.0501 * (0.03)
Climate	0.0534 (0.09)	0.0212 (0.04)	−0.0231 (0.09)	−0.0088 (0.04)
Distance	0.1955 (0.18)	0.0778 (0.07)	0.2111 (0.19)	0.0814 (0.08)
Weather			−0.1236 (0.16)	−0.0471 (0.06)
Constant	0.0354 (0.85)		1.3755 * (0.88)	
LR chi2	132.85		165.10	
Prob > Chi2	0.0000		0.0000	
Log likelihood	−220.96063		−203.4569	
Pseudo R^2	0.2311		0.2886	
Number of samples	415		415	

Note: ***, **, * indicate significance at the 1%, 5%, and 10% statistical levels, respectively, and standard errors are in parentheses.

4.1.2. Regression Results of the Second Round of Experiments

Considering the continuity of agricultural production, the behavior of farmers' adoption of innovative seeds technology in the second year may be influenced by the weather in the first year, so we take the weather condition encountered in the first round of the experiment as a control variable in the second round. According to the regression results (Table 6), the variable credit constraint is significantly negative at the level of 1%, consistent with the results in the first round of experiments, and hypothesis 1 of this paper is tested again. The coefficient of interlinked insurance and credit contract is significantly positive at the level of 5%, and interlinked insurance and credit contracts could promote farmers' adoption of innovative wheat seeds, and hypothesis 2 proposed in this paper is also tested again.

Among the control variables, unlike in the first round, household income is significantly positive at the level of 5%, and its marginal effect is larger than the marginal effect in the first round. The effect of income on innovative seed adoption is more pronounced in the second year, indicating that the farmers are more rational. As the experiment progressed, farmers understood the experiment more deeply, and their choice of innovative seeds required more household resources to cope with the occurrence of agricultural production risks. We can see that the weather condition in the first year is insignificant, which is different from some research [11], because smallholders, who are the main subjects of our study, mostly focus on satisfying their own consumption as the goal of agricultural production, and the induced effect of weather factors on the adoption of innovative seeds by farmers only occurs when the business goal shifts to the pursuit of market profits [61].

4.1.3. Robustness Test

We used three empirical methods to test the robustness of the relationship between credit constraint and the adoption of innovative seeds (Table 7). Firstly, we replaced the probit model with a logit model for regression analysis. Second, based on the psychological effect of self-protection, individuals may unconsciously seek the middle option that is more consistent with the majority perception when faced with attitude questions [62,63]. Therefore, in order to avoid extreme values from influencing our findings, we removed the sample of farmers who chose "1 = very difficult, 5 = very easy" in response to the question, "If you need 50,000 yuan for production turnover, how easy is it to borrow money?" Finally, considering that most elderly people do not have the ability to engage in agricultural production or business activities, and they are often not the implementers of household activities. Referring to the study of Li et al. [64], we performed a multivariate probit regression after excluding the sample of older people aged 60 years or older. As we can see from Table 7, the results are consistent with the baseline regression, both in terms of the significance of the regression coefficients and the sign of the coefficients, indicating that the estimation results of the model are robust.

Table 7. Analysis of the moderating effects of interlinked insurance and credit contract.

Variables	First Round of Experiments			Second Round of Experiments		
	Model Replacement	**Excluding Extreme Values**	**Transformation Samples**	**Model Replacement**	**Excluding Extreme Values**	**Transformation Samples**
Credit constraint	−0.8096 ***	−0.6013 ***	−0.191 ***	−1.0125 ***	−0.8725 ***	−0.169 ***
	(0.12)	(0.12)	(0.04)	(0.13)	(0.13)	(0.03)
Interlinked insurance and credit contract	1.0284 ***	0.4319 **	0.304 ***	0.9833 ***	0.4585 **	0.180 ***
	(0.26)	(0.17)	(0.07)	(0.27)	(0.19)	(0.06)
Weather				−0.2406	−0.3090	−0.0264
				(0.27)	(0.19)	(0.06)
Control Variables		Controlled			Controlled	
Regional dummy variables		Controlled			Controlled	
LR Chi2	132.69	79.00	91.14	164.21	115.68	91.14
Prob > Chi2	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Pseudo R^2	0.2309	0.1989	0.2445	0.2871	0.2931	0.2499
Log Likelihood	−221.0421	−159.1246	−141.2127	−203.9015	−139.5304	−136.7986
Number of samples	415	288	275	415	288	275

Note: ***, ** indicate significance at the 1%, 5%statistical levels, respectively, and standard errors are in parentheses.

4.2. Moderating Effects of Interlinked Insurance and Credit Contract

From the theoretical analysis, it can be seen that interlinked insurance and credit contracts can mitigate the inhibitory effect of credit constraint on farmers' innovative seeds adoption behavior effectively. In order to analyze whether the provision of interlinked insurance and credit contract facilitates the weakening of credit constraints and increases the adoption of innovative seeds by farmers. We used the group regression method to test the moderating effect of interlinked insurance and credit contract; in other words, we wanted to know the differences in credit constraint on farmers' innovative seed adoption behavior separately, taking into account whether interlinked insurance and credit contract are provided in the two rounds of experiments. The results are shown in Table 8.

Table 8. Moderating effects of interrelated insurance and credit contract.

Variables	First Round of Experiments				Second Round of Experiments			
	Not Available		Available		Not Available		Available	
	Coefficient	Marginal	Coefficient	Marginal	Coefficient	Marginal	Coefficient	Marginal
Credit constraint	−0.3060 *** (0.08)	−0.1219 *** (0.03)	−0.8876 *** (0.14)	−0.3448 *** (0.06)	−0.4645 *** (0.09)	−0.1796 *** (0.04)	−0.8800 ** (0.14)	−0.3250 *** (0.06)
Weather					−0.1933 (0.21)	−0.0740 (0.08)	0.0790 (0.29)	0.0294 (0.11)
Control Variables	Controlled				Controlled			
Regional dummy variables	Controlled				Controlled			
LR Chi2	49.21		109.69		64.78		121.86	
Prob > Chi2	0.0000		0.0000		0.0000		0.0000	
Pseudo R^2	0.1591		0.4223		0.2086		0.4704	
Log Likelihood	−130.0886		−75.0201		−122.8414		−68.5982	
Number of samples	224		191		224		191	
Experience p-value	0.000				0.014			

Note: ***, ** indicate significance at the 1%, 5% statistical levels, respectively, and standard errors are in parentheses. The "empirical p-value" is used to test the significance of the difference in the coefficient of "credit constraint" between groups, which is obtained using a seemingly uncorrelated model test.

From the results, it is clear that credit constraint significantly and negatively affects farmers' innovative seeds adoption behavior in both rounds of the experiment, regardless of whether an interlinked insurance and credit contract is provided, indicating that credit constraint is a strong factor affecting farmers' innovative seeds adoption [65]. Moreover, we can also draw the conclusion that the inhibitory effect of credit constraint on farmers' adoption of innovative seeds is stronger when an interlinked insurance and credit contract is provided. Compared to no interlinked insurance and credit contract offered, farmers' adoption of innovative seeds is lower, which is inconsistent with hypothesis 3 proposed in this paper. This suggests that interlinked insurance and credit contracts not only fail to effectively transfer farmers' risk but also reinforce the inhibitory effect of credit constraint on farmers' adoption of innovative seeds. As Giné and Yang conclude, the emergence of the interconnected credit and insurance model may provide a danger signal for farmers, and the adoption of innovative seeds makes farmers' agricultural behaviors risky [19], which results in a decrease in farmers' acceptance of innovative seeds. Furthermore, the mitigation effect of interconnected insurance and credit contract on farmers' credit constraints does not directly contribute to their adoption of innovative seeds [66]. Therefore, the mechanisms of their influence need to be further explored.

4.3. Further Analysis of Moderating Effects

Farmers' acceptance of innovative technology is positively correlated with their knowledge [19,33,67], and a lack of knowledge about complex information, such as insurance, may enhance the complexity of the technology diffusion process [3]. As a result, for further analysis, we regress the sample farmers' mean value of years of education. According to the regression results (see Table 9), in both rounds of the experiment, the interlinked insurance and credit contract is designed to guide the more educated farmers to adopt innovative seeds. The finding that farmers' educational level is significantly beneficial to raising the adoption rate of innovative seeds is supported by numerous documents [68], but the mechanism of the effect needs to be further verified.

Table 9. Interlinked insurance and credit contract and farmers' adoption of innovative seeds.

Variables	First Round		Second Round	
	Education $\geq$ 7.5	Education < 7.5	Education $\geq$ 7.5	Education < 7.5
Interlinked insurance and credit contract	0.170 ** (0.07)	0.140 (0.09)	0.102 * (0.06)	0.0830 (0.09)
Observations	247	168	247	168

Note: **, * indicate significance at the 5%, and 10% statistical levels, respectively, and standard errors are in parentheses.

Table 10 illustrates the regressions of the differences in farmers' adoption rates of innovative seeds regardless of the provision of interlinked insurance and credit contract. We can see that the educational level of households positively promotes farmers' acceptance rates if interlinked insurance and credit contract is not offered. Otherwise, the influence is not significant. Insufficient information and limited knowledge are generally considered to be the main factors that hinder the adoption of agricultural innovative seeds in general [50,69], while complex technology is usually knowledge-intensive and requires higher understanding abilities, so education may play a key role in promoting technology extension [67,70]. Interlinked insurance and credit contract, as a novel concept, is still in their infancy in China. Therefore, it is common sense that the education level of farmers is a key factor influencing their acceptance rate of innovative seeds.

Table 10. Differences in farmers' acceptance of interlinked insurance and credit contract.

Variables	First round of Experiments (Marginal Effect)		Second Round of Experiments (Marginal Effect)	
	(1) Treatment Group	(2) Control Group	(3) Treatment Group	(4) Control Group
Credit constraint	−0.345 ***	−0.122 ***	−0.325 ***	−0.180 ***
	(0.06)	(0.03)	(0.06)	(0.04)
Education	−0.0147	0.0379 ***	−0.00122	0.0281 **
	(0.02)	(0.01)	(0.02)	(0.01)
Control Variables	Controlled	Controlled	Controlled	Controlled
Regional dummy variables	Controlled	Controlled	Controlled	Controlled
Number of samples	191	224	191	224
LR chi2	109.69	49.21	121.86	64.78
Prob > Chi2	0.0000	0.0000	0.0000	0.0000
Log likelihood	−75.0201	−130.0886	−68.5982	−122.8414
Pseudo R^2	0.4223	0.1591	0.4704	0.2086

Note: ***, ** indicate significance at the 1%, 5% statistical levels, respectively, and standard errors are in parentheses.

Credit will naturally flow to the activity with the highest marginal returns if the financial market is perfect [71]. However, the insurance and credit markets are still imperfect in China, and a complete separation of consumption and production decisions is not possible, especially in rural areas of China [71,72]. The demand for complex insurance in China is limited because farmers may be implicitly covered by limited liability in the contract that combines credit with insurance and charge premiums that actually raise the interest rate on loans [19,72].

Giné and Yang, Farrin, and Miranda provide the positive interlink among the degree of education, the adoption of innovative seeds, and willingness to loan. Although innovative seeds have higher yields, they also have greater risks [1,19,37]. The relatively low level of education of farmers in the sample area and their lack of awareness of the potential benefits and the potential risks associated with more complex financial products made it difficult to eliminate farmers' distrust, even though the interlinked insurance and credit contract was explained in detail prior to the beginning of the experiment. Therefore, reducing the adoption of interlinked insurance and credit contract products becomes a reliable choice. The empirical study by Bewket concludes that the adoption and widespread diffusion of soil and water conservation technology are not sustainable for Ethiopian farmers [73], which is in line with our findings. According to Table 11, the average years of education of farmers in different groups are only 7.54 and 7.48; most farmers have not completed junior high school or higher education (≥9 years), and the lower education level results in farmers' inability to make accurate assessments of complex insurance terms. Therefore, the demand for interlinked insurance and credit contract in China's agricultural development process remains highly limited [42], and thus improving farmers' education will mitigate the inhibitory effect of credit constraints on farmers' adoption of innovative seeds.

Table 11. Test for differences in means.

Variables	Treatment Group	Control Group	Differences	P
Education	7.54	7.48	−0.06	0.8212
Risk	0.2128	0.2889	0.0761 **	0.0171

Note: ** indicate significant at the 5% statistical levels, respectively.

When comparing the farmers without an interlinked insurance and credit contract, their adoption of innovative seeds is 22% and 15% lower in the two rounds of experiments, respectively (see Table 8). It can be seen that farmers' acceptance rate of innovative seeds is higher in the second round of experiments than in the first round, which might be caused by the lag effect of farmers' adoption behavior of innovative seeds [67]. Gine et al. also argued that farmers' poverty might deem the information obtained from the initial experiments with a new technology of lower value and adopt it later [73].

Giné and Yang indicate that risk-averse borrowers prefer growing traditional varieties over adopting riskier hybrid varieties [19]. We compared the ambiguous risk preferences (Equation (9)) of the control and treatment groups. Table 11 shows that the mean value of ambiguous risk preferences of farmers in the control group is significantly higher than that of the treatment group, indicating that farmers in the treatment group are more risk-averse when they are borrowers. Therefore, the provision of interlinked insurance and credit contract will increase the acceptance of riskier hybrid varieties by risk-averse farmers.

5. Discussion

Based on data from the field experiment with 415 rural households in two Chinese provinces, this study explored the inhibitory effect of credit constraint on farmers' adoption of technology from the perspective of innovative seed technology. This study also explored the heterogeneity of rural households' adoption of innovative seeds with or without interlinked insurance and credit contract products. Compared with previous studies, the contributions of this study can be summarized as follows: (1) This study constructs a theoretical analysis and systematic framework of "credit constraint → interlinked insurance and credit contract → adoption of innovative seeds technology". (2) This study quantitatively explores the impact of credit constraints on farmers' adoption of innovative seeds. (3) This study further analyzed the factors that impede the demand for interlinked insurance and credit contract in current China's agricultural development using empirical evidence regarding the inhibitory effect of credit constraint on the adoption of agricultural technology. The study will also motivate policymakers to improve rural credit markets in order to alleviate farmers' credit constraints and thus promote the adoption rate of innovative seed technology. Last but not least, it will prompt government departments to provide diversified infrastructural support for innovative technology adoption, such as innovative seeds. Moreover, credit and insurance markets are boosting farmers' acceptance of innovative seeds.

Additionally, the results of our analysis show that credit constraint hinders farmers' adoption behavior of innovative seeds significantly. This result is consistent with the findings of Tesfaye et al. [43] and Boinec et al. [74], who indicated that reducing credit constraints benefits agricultural production. Specifically, credit constraint is a common problem faced by farmers in most developing countries. There are significant information asymmetries in rural credit markets, which may lead to adverse selection and moral hazard problems. Since innovative seeds are high-risk, high-return investments that require financial support, credit becomes an inevitable way of agricultural investment for small-scale farmers. The research results show that using financial tools can significantly promote the adoption of innovative seed technology [32,49,50].

In addition, the relationship between the control and dependent variables in this study is mostly consistent with the findings of previous studies. For example, Adebayo et al. [10] conclude that farmers with more years of education have a better understanding and responsiveness to new agricultural technology, and they are more likely to have more positive attitudes toward new technology. Our study finds that farmers with more years of education are more likely to adopt innovative seed technology. Similar to the findings of Li et al. [63], we found that household income is an important driving force for the adoption of innovative seed technology. Only farmers with sufficient financial support can afford the cost and are more willing to adopt innovative seed technology. Coinciding with the findings of Tang et al. [6] and Giné et al. [19], we validated the role of risk preferences in promoting technology adoption by rural households. We found that technology training cannot promote farmers' technology adoption behavior, which is inconsistent with Mariano et al. [75]. According to Table 5, the majority of farmers received less than one training session in the previous year, indicating that systematic technological training services for farmers in the study area require improvement.

The results of this study also validate the factors that impede the diffusion of interlinked insurance and credit contract products in developing countries. We found that interlinked insurance and credit contract products may further reinforce the inhibiting effect of credit constraint on farmers' adoption behavior of innovative seeds, which is inconsistent with Qiu et al. [32], Farrin et al. [37], Carter et al. [40], Liu et al. [49] and Li et al., who [50] all point out that the "credit + insurance" partnership approach is an effective way to help farmers access more capital. However, this study found that rather than alleviating the inhibiting effect of credit constraint on farmers' adoption of innovative seed technology, the introduction of interlinked insurance and credit contract product reinforces the exacerbation. Giné and Yang [19] specify that the emergence of interlinked insurance and credit contract may provide a dangerous signal for farmers and that the adoption of innovative seeds makes farmers' agricultural behavior riskier, hindering farmers' choice of innovative technology. Bridle et al. [65] argued that this may also be caused by the fact that the mitigating effect of interlinked insurance and credit contract on farmers' credit constraint does not directly contribute to farmers' adoption of innovative seeds and that the mechanisms of their influence are not yet to be explored. Our results suggest that farmers' demand for interlinked insurance and credit contract in rural China is still limited at the current stage.

Further, this study proposes the effectiveness of improving farmers' education to mitigate the inhibitory effect of credit constraints on the adoption of innovative seeds from a cognitive perspective. Giné and Yang [19], Hörner et al. [66], and Oyawole et al. [66] all argued that farmers' knowledge comprehension significantly affects their acceptance of innovative technology. In the field of agricultural technology production, the lack of understanding of complex information may increase the complexity of the technology product diffusion process. The findings of this study are also in line with the fact that innovative seeds are knowledge-intensive and complex technologies, and farmers are not sufficiently aware of the potential benefits and the potential risks associated with credit-insured interactive products. At this point, rational farmers may choose to refuse the new technology. In addition to this, Gine et al. [58] and Hörner et al. [66] argued that compared with rich farmers, relatively poor farmers might generate a lower valuation of the information obtained from the initial experiments with the new technology and thus adopt it later. Similar to his findings, farmers' acceptance of innovation seeds is 22% and

15% lower in the two rounds of experiments when interlinked insurance and credit contract is offered to farmers compared with no interlinked insurance or credit contract (see Table 8). In this paper, the acceptance rate of innovative seeds by farmers in the second round of experiments is higher than that in the first round, verifying the validity of the delayed effect of farmers' innovative seeds adoption behavior.

The findings of this study are consistent with the fact that smallholder farmers are mostly risk-averse. In contrast, risk-averse borrowers may prefer growing traditional varieties to adopt riskier hybrid varieties. Therefore, the provision of interlinked insurance and credit contract should, in principle, increase the acceptance of risk-averse farmers and thus mitigate the inhibitory effect of credit constraints on the adoption of innovative seeds by farmers.

On the other hand, there are still some shortcomings in this study that can be improved further.

(1) This paper uses cross-sectional data to explore the relationship between credit constraint, interlinked insurance and credit contract, and innovation seeding technology adoption. However, the relationship among them may be dynamic. Therefore, future studies can apply panel data to fill the gap of the time-varying issue. (2) Due to the limitations of field experiment implementation, this paper assumes technology adoption as an innovative seed technology adoption behavior. However, agricultural technology behavior is divergent. In future research, we can design more scientific and detailed field experiments to study farmers' adoption behaviors of different innovative technologies in a categorical manner and improve the research system. (3) The sample area and sample size of this paper are still limited and unable to reflect extensive findings. In future studies, we can focus on the differences in technology adoption behaviors among different areas, including eastern, central, and western China, or southern and northern China, to draw more comprehensive conclusions.

6. Conclusions and Policy Implications

The low adoption rate of new agricultural technology is one of the major obstacles faced by small farmers in China. In fact, the Chinese government has been committed to the development of seed technology and has made many efforts to promote the application of agricultural technology. However, factors such as the credit constraint hindered this process. At the same time, there is widespread recognition of the role of interconnected credit and insurance partnership models in promoting the adoption of agricultural technology. However, innovative seed technology is costly and long-lasting, and farmers' willingness to adopt it varies depending on different regions and crops.

Overall, the findings suggest that credit constraint is a strong variable that hinders farmers from adopting innovative seed technology and that the link between insurance and credit contract has a significant positive effect on farmers' adoption of innovative seed technology. Other factors that drive farmers' innovative behavior in introducing varieties are complex and diverse, including their education level, risk preference level, family income level, government technological service support, weather disaster information services, and distance to the nearest financial institution. It is worth noting that this moderating effect further indicates that the interlinked insurance and credit contract will further enhance the inhibitory effect of credit constraint on farmers' innovative seeds adaption behavior. Currently, domestic demand for tying insurance and loan agreements is relatively low; at the same time, there is a lag in the introduction of innovative seeds by farmers.

Based on the empirical findings, this study provides valuable insights for policymakers to develop strategies to encourage farmers to adopt innovative seed technology sustainably. In this regard, first of all, it is necessary to further ease credit constraints and promote farmers' adoption of innovative seed technology. Specifically, the agricultural financial policy and credit interest rate term structure should be improved to effectively solve the problem of information asymmetry in the credit market (adverse selection and moral hazard). At the same time, the cooperation space between rural insurance and credit institutions should be further expanded to promote the deepening of rural finance. The government adopts a more inclusive attitude, increases the innovation of agriculture-related credit products and services, expands the scope of mortgages and pledges of agriculture-related loans in accordance with laws and regulations, and increases credit support for key areas of agriculture. In addition, promoting the continuous improvement of farmers and financial literacy can also further ease credit constraints to a certain extent. Then, for banks and insurance institutions, it is necessary to strengthen benchmarking policy requirements and support China's three rural areas to make up for shortcomings.

Based on empirical results from winter wheat growers in northern China, this paper validates the effectiveness of promoting cooperative interaction between agricultural insurance and rural credit markets to facilitate innovative seed adoption promotion. The interlinked insurance and credit contract can effectively reduce farmers' uncertainties, providing a means to diversify agricultural investment risks while helping farmers solve their financial constraints and promoting the adoption of innovative seeds by farmers. Therefore, there is a need to further expand the scope of this model in China and enhance the linkage between the insurance market and the credit market.

In addition, government agencies need to provide basic support for the adoption of innovative technology, such as innovative seeds, through multiple channels. For example, the government can provide technological guidance for farmers to adopt innovative seeds through technical training and demonstrations and strengthen the publicity of natural disaster risks in agricultural production and meteorological disaster warnings to improve farmers' risk perception. It is evident that droughts and rainy days are bottlenecks to regional agricultural development, so it is necessary to strengthen publicity to help farmers avoid agricultural yield reduction caused by natural disasters and realize the transformation of agricultural development bottlenecks into potential agricultural development.

Finally, farmers' education levels need to be improved to enhance their understanding of interlinked insurance and credit contract products. Because the demand for interlinked insurance and credit contract is still relatively limited at the current stage of China's agricultural development, improving the education level of farmers can alleviate the inhibiting effect of credit constraints on farmers' adoption of innovative seeds. Increasing investment in rural education can improve the education level of farmers, thereby enhancing farmers' awareness of joint interlinked insurance and credit contracts and increasing farmers' acceptance rate of innovative seeds.

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Appendix A. Research Questionnaire

1. Interviewee:
What is your gender? (1 = male, 0 = female);
How old are you ___; what is your nationality ___? (1 = Han, 0 = minority);
How many years have you attended school;
Are you a party member (1 = yes, 0 = no);
Are you a village cadre (1 = yes, 0 = no);
Are you a household head? (1 = yes, 0 = no)

2. Head of household information: gender ___ ; age ___; attended years of schooling ___; whether party members ___ (1 = yes, 0 = no); whether village cadres (1 = yes, 0 = no)

3. Does anyone in your family serve as a village official or civil servant?___(1 = Yes, 0 = No)

4. You have been engaged in agricultural production for ___ years, planting wheat for ___ years and corn for ___ years.

5. Your family has a population of ___ people (statistical caliber: 1. households at home, students with a collective account and military personnel), of which, the population older than 65 years old and younger than 16 years old are

Among the labor force, there are ___ people who work at home (including ___ male labor force and ___ female labor force), and there are ___ people who work outside all year round (working outside for more than 9 months a year).

6. In 2020, the income of your family from farming is ___ Yuan; the income from farming is ___ Yuan; the income from business is ___ Yuan; the income from cadres' salary is ___ Yuan; the income from agricultural subsidy is ___ Yuan; the income from farming is ___ Yuan.

7. How many miles from your home to the nearest river? ___ and how many miles from the nearest financial institution such as rural credit society ___.

8. Is there a weather information officer in your village? ___ (1 = Yes; 0 = No); Does the village provide technological information services to prevent meteorological disasters? ___ (1 = Yes; 0 = No)

9. What is the total area of wheat planted in your household in 2020? ___ (mu)

10. What is the number of blocks? ___

11. Does your family have family members or relatives working in financial institutions? ___ 1 = Yes, 0 = No

12. If you need 50,000 yuan for production turnover, how easy or difficult is it for you to borrow? ___

1 = very difficult; 2 = some difficulty; 3 = okay; 4 = easy; 5 = very easy

13. Did your household purchase wheat planting insurance last year? ___ 1 = yes; 0 = no.

Appendix B. Experimental Design

Risk Preference Experiment

1. First stage istest game: tell the tested farmer that the bag contains three black cards and three red cards, and the rewards for drawing black cards and red cards are shown in Table A1 as reward plan A1 and plan B1, respectively. The farmer's choice is ___(Note: Only those who choose plan B2 are allowed to continue the game).

Table A1. Test Games (Yuan).

Risk Options	Plan A1		Plan B1	
	Red card 15	Black card 20	Red card 16	Black card 21

2. The second stage is formal testing: After respondents have tried and become familiar with the rules of the experiment, the investigator provides 10 sets of test games; each set of test games includes two reward options: low risk and high risk, and respondents made risky choices for all 10 sets of games. Respondents selected either Reward plan A2 or Reward plan B2 from each of the 10 sets of games, with Reward plan A2 being the low-risk option and Reward plan B2 being the high-risk option. The second stage focused on making respondents understand that their choice of risky option is directly related to their final payoff to ensure that the information they displayed about their risk preferences is true and credible. In this stage, this study sets up two premises to measure the degree of risk preference for both deterministic and ambiguous probabilities, respectively.

(1) (See Table A2.) Respondents are explicitly informed that there are three black cards and three red cards in the bag: the number of respondents choosing plan B2 ___.

Table A2. Experimental protocol.

Options	**Plan A2**		**Plan B2**	
	Red Card	**Black Card**	**Red Card**	**Black Card**
1	20	20	22	18
2	20	20	23	17
3	20	20	25	15
4	20	20	35	15
5	20	20	37	13
6	20	20	40	10
7	20	20	52	8
8	20	20	54	6
9	20	20	56	4
10	20	20	60	0

The first time a farmer jumps from plan A2 to plan B2 is option ___[number should be: 0–10]; let the farmer take any set of options for the actual experiment, and the farmer's reward is ___yuan [amount in the table * 0.1].

(2) (See Table A3) The respondents are explicitly informed that the bag contained six red and black cards of varying numbers and that only one color is known to have more cards. The number of respondents who choose plan B2 for the 10 sets of test games in Table A3 is ___.

Table A3. Experimental protocol.

Options	**Plan A3**		**Plan B3**	
	Red card	**Black card**	**Red card**	**Black card**
1	20	20	22	18
2	20	20	23	17
3	20	20	25	15
4	20	20	35	15
5	20	20	37	13
6	20	20	40	10
7	20	20	52	8
8	20	20	54	6
9	20	20	56	4
10	20	20	60	0

The first time the farmer jumps from plan A3 to plan B3 is the option ___ [number should be: 0–10]; let the farmer take any set of plans for the actual experiment. The payoff to the farmer is ___ [amount in table * 0.1].

3. The experimental scenario of "Interlinked insurance and credit contract"

Situational Assumptions: In the baseline experiment, it is assumed that the farmers have an initial capital of CNY 4200 at the beginning of the experiment. They also have two types of wheat seeds available before the first year of cultivation: No.0 seeds and No. 1 seeds are available. The production inputs and income under different weather conditions differed between the two seeds (See Table A4: In the first year, farmers are required to make a choice of wheat seeds between No. 0 seeds and No. 1 seeds. The differences in seeds, production inputs and income under different weather conditions of these two kinds of seeds are shown in Table A5. If farmers choose No. 0 seeds, their own capital is enough and can satisfy the demand of production; if they choose No. 1 seeds, farmers need to apply for a loan of CNY 1800 and submit collateral worth CNY 1800 (we assume that the farmers can afford). At the end of the year, if the weather conditions are good for growing wheat (good weather), the farmers who plant No. 1 seeds can obtain the collateral back after repaying the loan. However, when the weather is bad, the farmers who plant No. 1 seeds cannot repay the loan because there is no income from planting, and the bank will confiscate the collateral. This means that they will end up losing CNY 1800, meaning that they have gone bankrupt, and the final payoff recorded by the experimenter is CNY −1800. Other farmers who are not bankrupt continue the experiment, and the final payoff in this experiment is determined by the amount of money left in each farmer's hand at the end of the last year. The experiment is conducted for a total of two years. The weather conditions for each year are determined in a similar way as in the risk experiment, with each farmer drawing a random card from a black box containing four red cards and two black cards, with a black card representing bad weather and a red card representing good weather. Weather conditions are simplified into two categories: disaster and normal. Based on local meteorological hazards, the incidence of disaster weather in the experiment is determined to be 1/3. Before the end of each round of the experiment, the farmers decide the weather conditions they would encounter in that round of the experiment by drawing lots. Farmers are required to select seeds at the beginning of the year: No. 0 seeds is low-cost, low-return that have been applied for many years; No. 1 seeds is innovative seeds with relatively high costs and returns, which are highly influenced by weather and have 1.55 times higher losses than normal seeds in case of bad weather. Farmers do not know what the weather will be like that year when they make the decision, so it is a risky decision. Farmers who purchase No. 1 seeds have to take a loan from the bank and provide collateral of corresponding value, which will be returned to the bank when the loan cannot be repaid. The main parameters involved in the experiment, such as production inputs and planting income, are shown in the table below. Both control and treatment group experiments are conducted in two rounds, representing two cropping cycles.

Table A4. Experimental parameter settings Comparison of traditional and innovative seeds (Unit: Yuan).

Experimental Group	Seed Variety	Production Input	Loan	Premium	Planting Income (Good)	Balance (Good)	Planting Income (Bad)	Balance (Bad)
Control group	No. 0 seeds	4000	0	0	7000	7200	0	200
	No. 1 seeds	6000	1800	0	12,000	10,200	0	−1800
Treatment group	No. 0 seeds	4000	0	0	7000	7200	0	200
	No. 1 seeds	6000	2000	200	12,000	10,000	0	0

Table A5. Experimental parameter settings comparison of traditional and innovative seeds (Unit: Yuan).

Experimental Group	Seed Variety	Production Input	Loan	Premium	Planting Income (Good)	Balance (Good)	Planting Income (Bad)	Balance (Bad)
Control group	No. 0 seeds	4000	0	0	7000	7200	0	200
	No. 1 seeds	6000	1800	0	12,000	10,200	0	−1800
Treatment group	No. 0 seeds	4000	0	0	7000	7200	0	200
	No. 1 seeds	6000	2000	200	12,000	10,000	0	0

First round

Step 1, farmer attributes ___ (control group = 0; treatment group = 1); farmer's technology choice ___ (traditional seeds = 0; innovative seeds = 1).

Step 2: The farmer draws lots to determine the weather conditions they will experience during the year ___ (0 = bad weather, 1 = good weather).

Step 3: The farmer's annual fund balance is calculated in dollars ___ [balance*0.001], and the farmer is informed of the current status.

After the first round of experiments, the farmer's choice ___ (0=quit agricultural production and go out to work, 1 = continue agricultural production). Note to farmer: if you choose 0, there is no need to do the second round of experiments; if you choose 1, please conduct the second round of the same experiment while keeping the attributes of the farmer unchanged.

Second round

Step 1: Farmers' technology choice ___ (traditional seeds = 0; innovative seeds = 1).

Step 2: Farmers conduct a lottery to determine the weather conditions they will experience that year ___ (0 = bad weather; 1 = good weather).

Step 3: The farmer's annual fund balance is calculated as ___ [balance*0.001] and the farmer is informed of the current status.

The overall amount obtained by the farmer from the experiment is ___ Yuan.

In order to provide a global reference, we provide here the new experimental design parameters in USD.

(1 CNY = 0.14 USD).

Table A6. Experimental parameter settings comparison of traditional and innovative seeds (Unit: USD).

Experimental Group	Seed Variety	Production Input	Loan	Premium	Planting Income (Good)	Balance (Good)	Planting Income (Bad)	Balance (Bad)
Control group	No. 0 seeds	560	0	0	980	1008	0	28
	No. 1 seeds	840	252	0	1680	1428	0	−252
Treatment group	No. 0 seeds	560	0	0	980	1008	0	28
	No. 1 seeds	840	280	28	1680	1400	0	0

Appendix C. Pictures of the Research

Figure A1. Data research and farmer interaction. Source: Photographed and compiled by the authors in July–August 2021.

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Article

Tackling Comprehensive Evaluation of Tourism Community Resilience: A Probabilistic Hesitant Linguistic Group Decision Making Approach

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Abstract: Community-based tourism (CBT) has been adopted as an effective and practical solution to land use policies by governments that simultaneously pursue upgrading of local economy, conservation of local ecosystem and development of local communities. Confronting with new normality of detrimental eventualities in situated environments, destination management organizations (DMOs) or local governments have to employ effective governance strategies for fostering tourism community resilience in order to sustain development of CBT destinations. In viewing of that facilitating development through evaluation usually manifests as an efficient strategy in governance practices, this paper contributes to fill two main gaps in tackling comprehensive evaluation of tourism community resilience. Firstly, by noticing the fact that current literature overlooks processual characteristics of tourism community resilience, which originate from integration of disaster management and destination management (DM2), we have developed an analytical framework comprised of six attributes for comprehensively evaluating tourism community resilience. Secondly, aiming at the phenomena that cognitive assessments on attributes of tourism community resilience often exhibit complicate uncertainties caused by low-structured or ill-structured problem nature, we have put forward a powerful expression tool of probabilistic dual hesitant fuzzy uncertain unbalanced linguistic set (PDHF_UUBLS) to simultaneously capture evaluators' cognitive characteristics of decision hesitancy, bipolar epistemic notions and relative importance among assessments. Then by formalizing comprehensive evaluation of tourism community resilience as a multiple attributes decision making process, we construct an effective multiple attributes group decision making (MAGDM) approach with assessments in the form of PDHF_UUBLS. Theoretical analyses verify the effectiveness of our constructed MAGDM approach and also show the approach avoids potential information distortion in comparison with other approaches. Overall, this paper provides effective and pertinent solutions, with both analytical framework and methodology, to the urgent task of comprehensive evaluation of tourism community resilience in DM2 agenda, thereby is of apparent significance in governance practice of CBT.

Keywords: land use policy; community-based tourism; tourism community resilience; DM2; comprehensive evaluation; MAGDM; probabilistic hesitant fuzzy set; unbalanced linguistic set; information measure

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1. Introduction

Land use reforms have been continuously and innovatively carried out by many developing countries to tackle social and economic hardship of economically limited settings [1], especially in their rural areas and mountain areas [2]. Community-based tourism (CBT) implementations seek to improve living conditions and economic status of local communities as well as to avoid gradually disappearing in their identities and irreversibly damaging their environments [1,3]. The multiple-faceted and ambitious attributes of CBT intrinsically identify it as pertinent in providing a systematic solution to tourism-led local development, such as tourism planning to support overall socio-economic development, community empowerment and ownership in decision making, communal collaboration in managing and developing tourism assets, conservation of natural resources and cultural heritages, and quality visitor experiences by advocating host-guest interactions [1,3–5]. Therefore, in many developing countries [6], CBT plays a crucial role in supporting land use reforms with special respect to rural revitalization and local sustainable development [1,2]. However, many pioneering investigations have pointed out that the tourism industry holds high-level vulnerability to changes (such as disturbances and uncertainties [7–10], natural hazards [11–13], climate change [14–16] and epidemics [15,17]) within its operating contexts [1,18–20]. The embedded symbiotic mechanisms of CBT development intensify its complex interrelationships with social-ecological resources in support of functioning of tourism systems [10], which further exacerbates the exposure of CBT implementations to detrimental eventualities [15]. On the other side, the augmented vulnerabilities highlight the pressing need for tourism communities to build their resilience when confronting adversities, which is intrinsically required in the official goals of sustainable development [21]. Resilience reflects the ability of a system to adapt to changing environments, as such has been argued as a critical component of sustainable development [18,22–24]. When applying the concept to tourism for strengthening sustainable tourism development, CBT destinations must be viewed as evolving interdependent sub-systems [10] that co-adapt to specifics of situated place and markets, and especially to the aspirations and values of tourism communities [1,18,25,26], so as to successfully maintain and increase carrying capacity [4,10,27–32], competitiveness [27,33–36], and attractiveness [11,26,27,29,35,37–39]. With effective resilience practices, tourism communities will empower themselves to adapt rather than cease to be operating directly [1,11,15,40,41]. As might be assumed, tourism communities could gradually achieve sound resilience practices through diachronic processes of responding to and learning from contextual changes. However, new normality [17] that has been brought about by epidemics and other changes will not leave enough time to the diachronic processes. Moreover, with the traditional wait-and-see attitudes, little will be known by DMOs about the status quo of resilience building practices in tourism communities. More importantly, knowledge sharing and learning opportunities for quick substantial improvements will be blocked out from tourism communities. In fact, evaluating resilience practices of tourism communities is an essential part of learning and measurement for destination governance, which fosters effective self-improvements as well as enables the processes of resilience building to be monitored continuously in a systematic way [42]. With regard to this consideration, construction of appropriate analytical frameworks for addressing desirable attributes of tourism community resilience and corresponding comprehensive evaluation approaches have become urgent matters in governance practices of CBT destinations.

Currently, despite some remarkably instructive studies that operationalized classic resilience theory to address tourism resilience by emphasizing practical utility, there is still no globally agreed-upon framework for resilience evaluation [10], especially with the paucity in CBT schemes [43]. Representatively, in their generic sphere of tourism resilience, Cochrane [18] proposed the fundamentally functional elements for building tourism resilience and emphasized the crucial role that the economic sub-system plays in holistic tourism systems. Given a certain economic configuration in CBT implementations of Ecuador, Ruizballesteros [1] more largely advocated the inextricable functions which socio-ecological system (SES) holds in fostering the success of CBT development, thereby deriving a framework comprised of the factors that nurture their socio-ecological resilience. Further, based on the above work by Ruizballesteros [1], Sheppard and Williams [26] deduced another framework by emphasizing that individual-oriented factors also enhance overall tourism community resilience, but their framework also neglected essential factors that contribute to economic resilience of tourism communities. Similarly, with noticing that CBT implementations currently still often disregard the community's right to enjoy the benefits of tourism and the positive effects that community resilience holds to tourism development, Wakil, Sun, and Chan [10] elaborated the discourse of co-flourishing between community resilience and tourism development by emphasizing the implications of six community capitals of human, social, natural, physical, financial and psychological. Comparative case investigations on community resilience across countries, cultures and types of threats accentuated the role of economic element in community resilience [41], especially for those successful communities associated with tourism development [40]. Through detailed focal case studies on tourism communities, Maclean, Cuthill, and Ross [11] definitely outlined the crucial functioning of diverse and innovative economy in their proposed resilience framework. In his seminal work, Faulkner [7] provided another essentially instructive framework by accentuating the disaster management in tourism destinations management. Obviously, the framework by Faulkner [7] is also essentially right for resilience building [8,44], and Filimonau and De Coteau [20] further advocated to build tourism resilience by drawing on integration of disaster management and destination management (DM2). Straightforwardly, tourism community resilience naturally manifests itself in corresponding stages of the disaster management process [13,20,45]. However, the aforementioned analytical frameworks, which exhibit various generic suitability from different aspects for evaluating tourism community resilience, neglected the processual characteristics of resilience building in tourism communities. This phenomenon has been evidenced by consecutive case studies on representative areas from Peru [15], Sri Lanka [17], Turkey [46], and Australia [13,47], in which processual logic required by disaster management in destinations [7,8] have been overlooked and still only traditional reactive attitudes prevail in the tourism industry [20]. However evidently, proactive preparedness which is commonly included in disaster management processes [7,8,20,44] is capable of drawing on comprehensive knowledge of previous crises and disaster management to offer a holistic perspective with regard to integrated strategies and frameworks, pertinent models, and contingency plans [46,48]. More fittingly to notice, in their most recent study, Jiang, Ritchie, and Verreynne [13] took the processual view to put forward a dynamic capabilities-oriented framework for tourism businesses to develop resilience in a disaster context rather than the view of SES approach [1,25] to accommodate the tourism community in a destination, especially neglected the socio-ecological issues emphasized in above-discussed classic resilience frameworks [1,10,11,18,26,40,41]. Therefore, in this paper, inspired by the above pioneering contributions, we will propose another analytical framework for comprehensive evaluation of tourism community resilience, which includes to emphasize processual attributes that reflect fundamental requirements by integration of disaster management and destination management (DM2) [7,8,13,20,44,46,47,49,50].

More important to notice, in focal literatures, the continuous development of analytical frameworks unanimously preferred qualitative attributes for comprehensive evaluation of tourism community resilience. In fact, the interwoven status of socio-ecological system and economic system in CBT intrinsically characterizes tourism community resilience with context-specific qualitative attributes due to its inextricable manifestation on social resilience [25], thereby bringing out a high degree of complexity in its comprehensive evaluation. Contextual complexity entails obvious difficulties in effectively expressing uncertain cognitive assessments on those qualitative attributes as well as constructing appropriate comprehensive evaluation approaches. It is worth noticing that, multiple attributes decision making (MADM) theory and its extensions to uncertain environments [51], such as fuzzy set-based methods [52–55] and linguistic set-based methods [56–59], have exhibited extensive suitability and flexibility in tackling comprehensive evaluation problems with qualitative attributes of high-degree complexity [60]. During the MADM modelling process for comprehensive evaluation, the foremost task is to develop appropriate expression tools for effectively depicting experts' complex opinions with considering multi-faceted cognitive characteristics, such as decision hesitancy [61], bipolar epistemic notions (membership and nonmembership degrees) [62], differentiated relative importance among hesitant assessments [63,64], etc. Due to the fact that the above cognitive characteristics apply simultaneously in complicate decision making processes, the combined effect on expressing assessments gives rise to development of compound expression tools that are capable of capturing and depicting assessments of high complexity more completely and comprehensively [65,66]. Recently, with special regard to evaluation problems with low-structured or even ill-structured qualitative definitions to which linguistic variables are preferably suggested [67], Pang, Wang, and Xu [63] and Xie et al. [68], respectively extended to introduce the compound expression tools of probabilistic linguistic term sets (PLTS) and dual probabilistic linguistic term set (DPLTS), which manage to utilize several hesitant linguistic labels to denote group basic assessments as well as collective complementary probabilistic opinions to each of the linguistic labels. Moreover, equally important in many practical cases where voting majority rules apply, group opinions of decision units will arrive at a linguistic label or a linguistic interval but obviously there still exists decision hesitancy to the voted [65]. In viewing of the same scenarios in practice, and by concurrently considering uncertain unbalanced linguistic scaling-based approximation [69], decision hesitancy, and bipolar epistemic notions, Zhang, Qi, and Liang [66] generalized to put forward a powerful expression tool called interval-valued dual hesitant fuzzy uncertain unbalanced linguistic set (IVDHF_UUBLS). Although IVDHF_UUBLS attains wide applicability in accommodating comprehensive evaluation problems of high complexity, IVDHF_UUBLS overlooked to address complementary group probabilistic opinions on supportiveness to membership degrees or nonmembership degrees as suggested by Pang, Wang, and Xu [63]. Therefore, in this paper, we will construct another enhanced expression tool of probabilistic dual hesitant fuzzy uncertain unbalanced linguistic set (PDHF_UUBLS) by extending IVDHF_UUBLS to probabilistic information environments.

Taking a step further, when confronted with the same obstacles as in conventional hesitant MADM that two hesitant fuzzy elements for comparison usually do not hold the same length, the fundamental modules (such as distance measures [70], entropy measures [71], similarity measures [70], and correlation measures [72]) required in modelling of group MADM approaches under PDHF_UUBLS environments also demand a certain mechanism that is capable of rationally extending any unmatched set, i.e., membership set or nonmembership set, of hesitant fuzzy elements for comparison to have equal length so as to be ready for further computational operations [73]. Currently, in the settings of probabilistic hesitant information, subjective extension mechanisms (i.e., through filling in a set with enough pairs of corresponding maximum, minimum or average values and zero probability to let the set have the same matched length) are still generally adopted [63,74]. Not only that they can hardly keep the original statistical feature value unchanged after extension, the above traditional subjective mechanisms also will result in zero-value phenomena due to setting of zero probability for all added data of derived utility sets which then are fed into information measures used by decision making processes [75–77], thereby causing more obvious information distortion with increment in the total amount of values added by subjective extension mechanisms. Interestingly, differing from the subjective extension mechanisms, the special extension solution based on least common multiple (LCM), which was originally put forward for neutrosophic hesitant fuzzy decision-making environments [78,79], provides another effective rationale that utilizes LCM to determine the common length of unmatched hesitant fuzzy elements rather than supposedly referring to the subjective choices. Inspired by the LCM extension mechanism, in this paper, we generalize it to our PDHF_UUBLS environments by adopting LCM as the common length for any unmatched membership set or nonmembership set and then uniformly allocating original probabilistic values to the multiplied membership or nonmembership degrees, so as to avoid subjective data interpolation and the potential information distortion caused by zero-value phenomena mentioned above. Furthermore, on the ground of LCM-based extension mechanism, information measures for IVDHF_UUBLS will be developed, by which an effective MAGDM approach under IVDHF_UUBLS environment will also be constructed and verified.

The rest of this paper is organized as follows. In Section 2, we establish an analytical framework by emphasizing processual characteristics of tourism community resilience and formalizing the task of comprehensive evaluation of tourism community resilience through the lens of multiple attributes group decision making. To effectively elicit complicated cognitive opinions of decision makers, Section 3 defines the probabilistic dual hesitant fuzzy uncertain unbalanced linguistic set (PDHF_UUBLS). In Section 4, we firstly extend to develop the LCM-based extension mechanism for PDHF_UUBLS, which enables operational laws for and decision-making approaches based on PDHF_UUBLS to fundamentally avoid potential information distortion in comparison with other methods. Then, the distance measure, entropy measure, and cross entropy measure for PDHF_UUBLS also have been developed in Section 4. Further, aiming at the complicated task of comprehensive evaluation of tourism community resilience, Section 5 constructs an effective multiple attributes group decision making (MAGDM) approach under a PDHF_UUBLS environment. Especially, with respect to common observations where weighting vectors for both evaluative attributes and decision units cannot be subjectively determined in advance due to complexity, programming models have been developed to objectively derive the unknown weighting vectors. Section 6 illustrates our proposed approach. Finally, conclusions are made in Section 7.

2. Problem Description of Comprehensive Evaluation of Tourism Community Resilience

2.1. Analytical Framework for Comprehensive Evaluation of Tourism Community Resilience

From the perspective of systemic thinking, community-based tourism (CBT) could be recognized as the special type of synthetized tourism system that draws on the locally situated social ecological system (SES) and tourism economic system [80], while the tourism economic system is naturally grounded on the SES [10]. Tourism community resilience basically emphasizes the tourism community's capacity of adapting, learning, and self-organizing in confrontation with detrimental eventualities, such as internal crises and external disasters [20,26]. Building tourism community resilience is obviously a non-linear management task [20] and its successful implementation must rely on adaptive governance that advocates co-management schemes [25]. This underlying observation explains that pioneering analytical frameworks suitable for comprehensive evaluation of tourism community resilience have been constructed to be more inclined to adopt qualitative attributes [1,10,11,18,26,41]. On the other side, the amplifying facts that CBT and other practices in tourism industry are truly impacted by crises and disasters have been sufficient to prompt integration of destination management and disaster management (DM2) [7,20]. In fact, in their seminal integrated managerial frameworks, Faulkner [7] and Ritchie [8] have already established the processual linkages between destination resilience building and disaster management [20], thereby characterizing tourism community resilience in CBT with indispensable processual attributes [13]. Despite the seminal integrated DM2 frameworks by [7,8], which accentuated a proactive attitude rather than only the reactive one through a cyclical and revolutionary processual view, most studies only took a reactive stance to evaluate disaster management in CBT destinations [20,50] and case studies in CBT destinations (form emerging markets [17,81] to well established markets [46,82], where small and micro businesses as the majority cannot individually fulfill the requirements of disaster management due to their limited resources and capabilities [13]) also indicated practices of disaster management still basically get along with reactive visions. From the opposite side, this predominantly inopportune prevalence of reactive stance spotlights the significance in carrying out comprehensive evaluation of tourism community resilience for effectively building resilience in CBT contexts. Therefore, inspired by the above-mentioned analytical frameworks relevant to disaster management and destination management in CBT, in the following, for comprehensive evaluation of tourism community resilience, we take view of processual logic from the integrated DM2 frameworks [7,8] and system thinking of SES approach [1,25] to derive a pertinent framework that comprises of six attributes, i.e., developing proactive preparedness, raising reactive readiness, fostering diverse and innovative economy, nurturing sense of community, consolidating organizational structure of tourism community, and advancing leadership as the core of governance. In the following, we elaborate the derivation of the above six attributes and summarize their corresponding descriptors for comprehensive evaluation in Table 1. For more clarity, in Figure 1, we also demonstrate our proposed analytical framework and list concise key points to each of its six attributes.

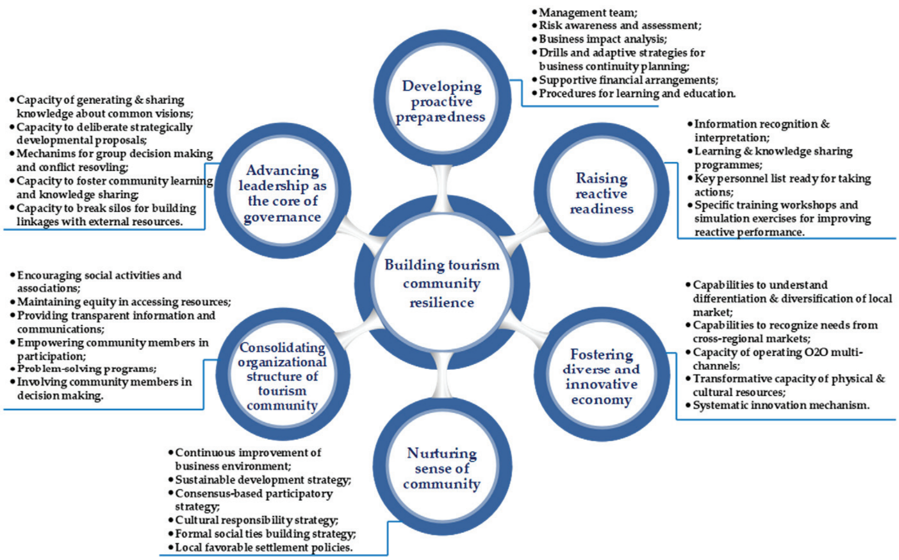

Figure 1. Illustration of proposed analytical framework for comprehensive evaluation of tourism community resilience.

Developing proactive preparedness. In tourism communities' building resilience against new normality of contextual disturbances [17], proactive preparedness plays a crucial role [83]. Without precautious attitudes and actions, consequences of detrimental eventualities will be prolonged and even exacerbated, thus with greater chance resulting in collapse of functional sub-systems in a tourism community [15,20,81]. The more severe, enduring and surprising the eventualities which tourism communities encounter, the stronger the resources must be prepared to build resilience [7,17,83–85].Proactive preparedness normally refers to, with attitudes of anticipation and active sensing, the process of building readiness through effective planning to deal with detrimental eventualities [7,8,46,86,87]. Since tourism communities generally are facing loss of tangible assets to various extent due to their vulnerability to potential eventualities [13], risk assessment for identifying vulnerability must be included in proactive preparedness in the first place [7,8]. Understanding potential risks and their impacts on tourism communities' vulnerability provides essential directions to formulate effective contingency plans [81]. Thinking systemically, customers, stakeholders and external industrial partners all demand business in tourism communities to adaptively remain vibrant when going through disturbances and uncertainties. Therefore, to avoid fundamental dysfunctions of the local tourism system, business continuity planning must be foremost focused on proactive preparedness of contingencies. Apart from assimilating experiential or officially approved procedures, by considering governmental instructions and guidelines [88,89], to formulate written routine drills [85], business impact analyses also have to be implemented carefully to identify a key set of interdependent basic functions and their alternatives [90]. More importantly, adaptive strategies that enhance tourism communities' resilience should also be reflected into business continuity as sustainable goals in alignment with severity of disturbances. As suggested by Jiang, Ritchie, and Verreynne [13], procedures of business operational adjustment, production adaptation and development, business model adaptation and expansion, and labor retention should be included in a business continuity plan for short-term planning; facilities expansion, infrastructure restoration, infrastructure modernization, and industry innovation for long-term planning. Halibozek and Kovacich [90] reminded that any innovative proposals should meet the cost-efficiency criterion. From the processual view, constructing proactive preparedness is an iterative process and it requires interactively supportive ingredients to form a cycle of reflection [7,81]. To keep instantly effective and complete awareness of contextual changes [20], data collection and reporting systems should be swiftly established through public communication approaches [13,91]. A delegated management team, which is a permanent and integral feature of business continuity planning, should be appointed in charge of plan development [7]. A communication center which facilitates bi-directional informing should also be operationalized as a regular infrastructure rather than only in the ad hoc mode as criticized in many studies [50,88]. In viewing of common specificities in tourism communities where small and micro-businesses constitute the most and generally behave weakly to proactively prepare financial resources for effectively adapting to changing environments [17], arrangements for acquiring financial resources definitely should be covered in business continuity planning, such as business insurance [17,47,83], business contingency funds [47], and government grants and funds [47,85]. Furthermore, clearly knowing and understanding detailed planning for changes by all stakeholders would be crucially essential in forming proactive posture of tourism communities [92], mechanisms for learning and education thus have also been stressed by the literature as an imperative in practices [1].

Raising reactive readiness. Literatures regarding crises and disaster management in the tourism industry have also gone through rather deep discussion and reached a common understating that both proactive preparedness and reactive readiness are indispensable for resilience building in tourism communities [7,8,17,20,81,86,93], because active anticipation and sensing does not necessarily mean the planned actions will be taken quickly and effectively [88]. Reactive readiness-oriented strategies thus focus on quick and efficient execution of planned actions in front of complicated changes or unexpected eventualities [90]. To bounce against those scenarios, tourism communities' proactive infrastructures of awareness (such as early warning systems and data reporting systems) are generally incapable of indicating what actions to directly follow. So tourism communities have to nurture the capacity of information recognition and interpretation for mapping various scenarios to a set of relevant planned actions [85], such as forecasting and case-based reasoning systems [85]. According to social organization perspective of community resilience construction [94], member businesses in a tourism community play a fundamental role in catalyzing holistic community capital through their key functions in increasing the potential of local networks [50]. Analogically, member businesses' performance of reactive readiness therefore determines the overall level of reactive readiness of the tourism community. However, member businesses generally are in lack of such skill sets or knowledge required in planned actions against new normality of changes [17]. Then, it is essential to include learning programs that empower the owner-operators or staffs in order to maintain relevant personnel on the contact list and take key actions by leveraging their knowledge [95]. With special respect to responding speed and effectiveness of stakeholders, skills-related and scenario-specific training workshops are critical tools and should be routinely conducted to practice drills required in action plans, such as training programs regarding disaster or crisis-related events, training of new media communications and tourist/guest handling [50,85]. To gradually understand real scenarios that planned actions apply, Malhotra and Venkatesh [88] suggested simulation exercises might be carried out to inform community members with integral consciousness, thereby improving their agency in reactive preparedness.

Fostering diverse and innovative economy. Successful engagement within markets is vital to the resilience of tourism communities, otherwise any tourism system will come to collapse without pertinent configurations of economy in a tourism community [18]. From the view of developmental dynamics in going through contextual market changes, planned adaptive strategies for continuity of member businesses must be based on, derived from, and manifest on current configurations of economy in tourism communities. By identifying their susceptibility to market changes, many pioneering studies on community resilience have indicated the importance of community's avoiding simple operations in a certain sector, thus encouraging a diverse and innovative economy [11,40,41]. To effectively cope with changes, resilience theories acknowledge the needs for catering to evolutionary interests of customers and simultaneously recognize new opportunities that changes generate [11]. During the processes of pursuing diverse and innovative economy, tourism communities should figure out approaches that nurture customers' willingness to support local business and community members' willingness to support each other with interests of improving everyone's opportunities [40]. More practically with respect to their specificities, tourism communities have to take strategies that consider both the demand side and supply side of the market. From the demand side, continuous improvement mechanisms for tourism products and services are fundamental to keep up with changing demands. To reinforce the mechanisms, market investigation and differentiation is essentially important in acknowledging customers' needs diversely and precisely. Exploring and exploiting regional customers' profiles and feedbacks from both online and offline can help firmly seize the local market since tourism communities are largely locale-specific, while analysis on cross-regional customers can help tourism communities stay well-informed and capture potential needs and overall trends in a broader view. From the aspect of supply side, a strong local focus should be emphasized by innovatively drawing on locally characterized physical and cultural resources [11]. Diverse catalytical streams of tourism economy should be further incorporated, such as research and education applications that value and communicate local landscape and cultural heritage, experiential applications that enjoy local lifestyles, and e-commercial projects that foster market development and enhance robust revenue for all available local specialties. All the projects and applications should be implemented as common projects and operated as a mechanism to benefit the possible majority of tourism community members. In general, diverse and innovative economy is an intrinsic attribute that indicates economic adaptive capability of tourism communities in front of various changes.

Nurturing sense of community. Taking tourism community as human environment interdependent context [96], fostering sense of place can enhance community members' willingness to take responsibility rather than to pull out without persistence in adapting to uncertainties and adversities [11,97], which is a prerequisite for a community to demonstrate collective competence [94]. Environmental psychology has indicated place attachment is commonly adopted in addressing sense of place, and generally two interrelated components of place attachment (e.g., place dependence and place identity) have been proposed within a wider array of theoretical frameworks, embodying functional and emotional ties to a place [98]. As can be seen, tourism communities as economic contexts produce functional place dependence to their community members, who rely heavily on market-oriented tourism systems to gain economic incomes and benefits. Therefore, continuous strategies for business environment improvement should be applied to enhance the tourism systems [10], which can be typically derived as maintenance and development of attractions, improvement on institutional services, improvement on tourist infrastructures, deployment of multimedia destination marketing and branding, etc. Systemic views of human-environment connections also indicate that socio-ecological resources underpin and produce functional dependence to community members [10,26]. So, effective sustainable strategies at local level should be incorporated, such as those often suggested ones including preservation and protection of cultural and natural landscapes [11], mechanisms for environmental management (e.g., appropriate monitoring and protection), advocation of pro-environmental narratives [99], and standardization of waste management [29]. Regarding the emotional people environment contexts in tourism communities, place identity facilitates community members' internalizing collective norms, defending collective interest, then taking shared responsibilities [100]. Place identity manifests when community members gain belief that they share values and goals with the community [101]. In the pioneering study situated in community-based tourism, Ruizballesteros [1] suggested common goals and interests shared are compulsory and should be guaranteed by consensus-based participatory strategy. Emphasizing and nurturing cultural responsibility to the community and its country helps to formalize shared feelings about historical trajectory of the place, thereby developing their place identity as connections to place [11]. To this end, measures thus should be taken not only focused on the ones for protection, but also those for continuous sensemaking, promotion, and development. Considering the fact that tourism development endows community members with combined roles of residents and business practitioners, the job embeddedness theory [102] applies and presents two ways of organizational embeddedness and community (living) embeddedness to construct place identity. However, in comparison with conceptualization of social capital [97], job embeddedness theory more emphasizes building formal (organizational) ties to enhance tourism community members' place identity, thus corresponding strategies that encouraging membership of business associations, industry associations, and other supportive NGOs should be recommended. On the other side, besides that amenities of tourism communities can provide preferable lifestyles, community (living) embeddedness [102] advocates local favorable settlement polices (e.g., the beneficial accommodation policies for newcomer entrepreneurs introduced by local government in China) should be well established to let community members not only be close to the community but become part of it, thereby generating place identity [101].

Consolidating organizational structure of tourism community. Adaptation processes required in building resilience of a tourism community are primarily social and depend on community members' drawing on their social capital [97,103]. Pioneering studies regarding community resilience have pointed out that social capital should not only keep focused on resource potential represented by personal network ties but more importantly and profitably on the concept of organizational structure of a synergized collectivity, transcending the agentic aspect of community members over a perspective centered on the accumulation of stocks of resources [104]. Organizational structure indicates how efficiently a tourism community can organize and work together to advance their common goals [105]. In the context of building resilience in tourism communities [14], organizational structure shows how community members are networked and how well they work together in dealing with adversities and uncertainties [106]. Overall synergetic level of organizational structure in a resilient community manifests on residents' reliable social ties between each other and collective efficacy, which support mutually to catalyze adaptive capacities of community as a social organization [94,106–109]. Social trust always occupies the core of social capital conception [97], and its function is straightforward in building social ties, thereby continuously maintaining and consolidating structures of community networks [97]. Therefore, social trust usually serves to measure the stability of organizational structure when community members work together [94,110]. Often argued effective strategies for fostering social trust in communities generally include encouraging citizens' participation in social activities and voluntary associations to build their social networks among community members [111–113], maintaining citizens' equity in accessing community resources [114], and providing transparent information and communication [114]. However, community networks with solid ties may only foster conditions under which collective efficacy flourishes but network ties are not sufficient for the exercises of collective control and actions [115]. Collective efficacy directly reflects linkages of trust and cohesion with shared expectations of participation and cooperation in organized community actions [107,116,117], thereby indicating collective efficiency of networked tourism community members' working collectively to deal with changes [94,108]. In view of the fact that collective efficacy closely relies on empowerment of community members, extant studies thus suggested to adopt useful strategies for its continuous improvement, mainly including participatory processes regarding community development as vehicles to empower community members [41], problem-solving programs to build community agency and self-organizing capacities [1,26], especially the substantive empowerment that allows community members to involve in decision making activities [84].

Advancing leadership as the core of governance. Special emphasis has been remarked to the importance of leadership in effective governance practices towards resilience building in tourism communities [11,18,25,40,118], because it is crucial in providing directions and synergies of joint actions to adaptation, as well as in initiating and guiding transformation to change [8,11,25]. Standing from the strategic position to achieve long-term shared interests of tourism community members, leadership should be capable of developing common visions and implementing them in sustainable planning [1,80]. Knowledge about the common visions should be well-generated and communicated to catalyze agency and self-organizing for goal accomplishment [11,41]. By acknowledging the complexity in managing and marketing tourism community within a CBT destination, those in leadership have to deliberate strategically developmental proposals that benefit the whole tourism community, such as arrangements of complementary tourism products and services, establishments of common norms and regulations for guaranteeing consistent tourism products and services and creating and nurturing local online brands. To that end, more tactically, group decision-making mechanisms that involve stakeholders of focus should be institutionalized since engaged governance revolves around participation and collaboration [11]. During processes of group decision making, leadership's ability to act as a mediator for conflict resolution is fundamentally important [1,10], especially helping arrive at opportune decisions to tough conditions [8]. The common feature that tourism communities are comprised of small businesses entails the common phenomena that contextual changes facilitate outages of community members' knowledge for keeping up with changes. Generally, participation and collaboration embody processes through which community members and other concerned stakeholders pool their knowledge so as to expand and enrich collectively shared information, knowledge, and ideas [119]. Therefore, leadership should operationalize as another mechanism which fosters knowledge sharing and community learning through training and education, aiming at spillover of knowledge pool for members' innovation and collective competitiveness. In view of that many failures of community-based tourism also have been ascribed to lacking of linkages with external tourism distribution channels and markets [3,120], leadership thus must manifest the capability of breaking silos for building linkages with external resources [95], such as optimal resource bundling for small businesses [121], inward funding and investment [10], and beneficial government policy [10].

For more clarity, we have organized the above six attributes and their descriptors in following Table 1.

Table 1. Analytical framework for comprehensive evaluation of tourism community resilience.

Attributes	Attribute Descriptors for Comprehensive Evaluation
C_1: Developing proactive preparedness	· Rationally configured management team who are in delegation to develop and improve a business continuity plan for their tourism community; [7] · Mechanisms and infrastructures (such as data collection and reporting [13,91], communication center [50,88]) for facilitating risk awareness and assessment; [7,8,81] · Precise business impact analysis that identifies a key set of interdependent basic functions and their alternatives; [90] · Context-specific written action drills for business continuity planning, which assimilate experiential or officially-approved procedures by carefully referring to governmental instructions and guidelines; [85,88,89] · Cost-efficient adaptive strategies for both short-term and long-term business continuity planning; [13,90] · Supportive financial arrangements to help operating businesses (especially, the major small and micro sized ones) proactively prepare financial resources [17,47,83,85]; · Procedures for learning and education to effectively shape proactive posture of the tourism community; [1,92]

Table 1. *Cont.*

Attributes	Attribute Descriptors for Comprehensive Evaluation
C_2: Raising reactive readiness	· Capabilities of information recognition and interpretation for mapping scenario to planned actions [85]; · Learning and knowledge sharing programs that guarantee and empower a key personnel list from member businesses ready for taking actions [95]; · Specific training workshops that practice drills required in action plans in order to improve responding speed and effectiveness of stakeholders [50,85]; · Simulation exercises that refer to real scenarios and aim at raising performance of reactive readiness [88];
C_3: Fostering diverse and innovative economy	· Capabilities to precisely understand differentiation and diversification of needs/motives from local markets; · Capabilities to agilely recognize potential needs and overall trends from cross-regional markets; · Capacity of member businesses to operate by product mix and through O2O multiple channels; · Diversely tourism-oriented transformative capacity of physical and cultural resources; · Systematic innovation mechanism that captures market opportunities and carries out developmental projects to benefit stakeholders in the community;
C_4: Nurturing sense of community	· Practices of strategies for continuous improvement of business environment in the community [10]; · Practices of strategies for sustainable development [10,11,26,29,99]; · Practices of consensus-based participatory strategy for guaranteeing common goals and shared interests [1]; · Practices of strategies for emphasizing and nurturing cultural responsibility [11]; · Practices of strategies for advocating formal ties building in the community [97]; · Practices of strategies for advocating local favorable settlement polices [101,102];
C_5: Consolidating organizational structure of tourism community	· Encouraging participation of community members in social activities and voluntary associations to build social networks [111–113]; · Maintaining community members' equity in accessing community resources [114]; · Providing transparent information and communication [114]; · Empowering community members in participatory processes for community development [41]; · Effective problem-solving programs aiming at building agency and self-organizing capacities of the community [1,26]; · Substantive empowerment that allows community members to partake in decision-making activities [84];
C_6: Advancing leadership as the core of governance	· Capacity of generating and communicating knowledge about shared common visions of the community [11,41]; · Capacity to deliberate strategically developmental proposals that benefit the whole tourism community; · Effective mechanisms that organize stakeholders for group decision making and resolve conflicts [1,8,10,11]; · Capacity to foster community learning and knowledge sharing [119]; · Capacity to break silos for building linkages with external resources [10,95,121];

2.2. Formalizing Comprehensive Evaluation of Tourism Community Resilience

Increasing disturbances and changes in situated internal and external environments, especially the profound detrimental influences brought about by the outbreak of pandemics, have been compelling destination management organizations (DMOs) and local related governments to integrate destination management and disaster management (DM2) [20]. The proposal of integrative action framework of destination management and disaster management has expanded to include a portfolio of unprecedented tasks [20], among which building tourism community resilience emerges as an urgent one. As elaborated above, building resilience cannot be treated as a diachronic process when contextualized with detrimental eventualities of high frequency [17]. As a result, DMOs and local governments all over the globe have to take pertinent strategies to prompt tourism community resilience building. In alignment with various countries' institutional experiences [42], the strategy of promoting development through evaluation provides an appropriate and efficient governance strategy. The fundamental logic underlying the strategy is that, based on the ranking results derived from comprehensive evaluation, awarding and stimulation can be then applied and function as motivational mechanisms in which resilience-building performances of tourism communities would be efficiently improved through iterative knowledge sharing and purposeful learning. Therefore, comprehensive evaluation of tourism community resilience has become an inextricable task in the integrative practices of destination management and disaster management (DM2). Furthermore, complexity in attributes of tourism community resilience as introduced in Section 2.1 leads to decision-making processes in which assessments on those attributes inevitably will be determined qualitatively by elected decision makers (or decision units) according to their trusted expertise. Subsequently, in this paper, we conceptualize the problem of comprehensive evaluation of tourism community resilience with holding the multiple attributes decision making process as shown in Figure 2.

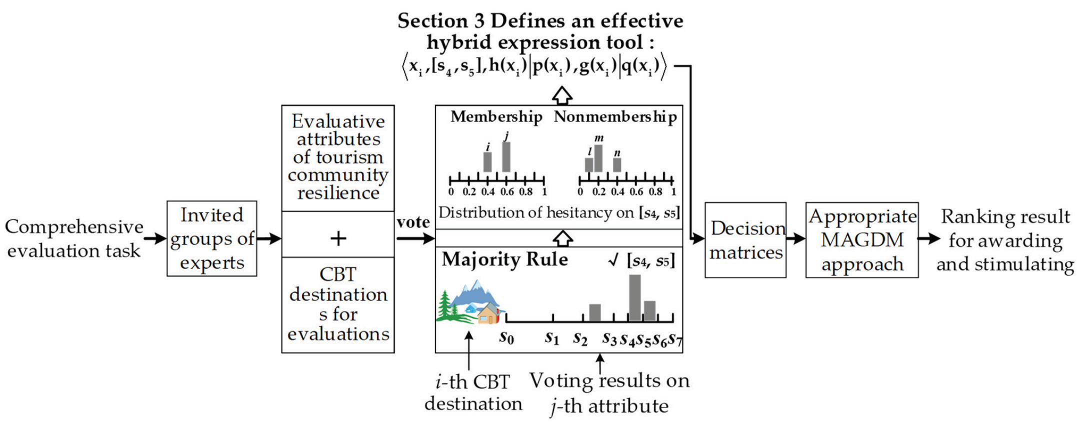

Figure 2. MAGDM-based approach with considering compound assessments of high uncertainty to comprehensive evaluation of tourism community resilience.

According to Figure 2, the problem can be formally expressed as follows. Given an NGO or a local government, there are a set of CBT destinations, i.e., $X = \{x_1, x_2, \ldots, x_n\}$, under its administration. Let $A = \{A_1, A_2, \ldots, A_m\}$ denote the attributes introduced in Section 2, according to which elected decision makers or decision units will comprehensively evaluate status quo of tourism community resilience in each CBT destination. The NGO or local government will invite several groups of experts, $E = \{E_1, E_2, \ldots, E_t\}$, to present their assessments to each CBT destination $x_i(i = 1, \ldots, n)$ under each attribute $A_j(j = 1, \ldots, m)$. To facilitate elicitation of complicated assessments by decision makers, the compound expression tool of PDHF_UUBLS, which will be further thoroughly analyzed in Section 3 is employed to depict the assessments more effectively and integratively. Then, a certain number of decision matrices whose elements are in the form of PDHF_UUBLS will be collected and fed into appropriate multiple attributes group decision making (MAGDM) approaches. In order to construct effective MAGDM approaches under PDHF_UUBLS environments, in the following sections, we will introduce the detailed definitions of PDHF_UUBLS and its desirable information measures.

3. Definition of PDHF_UUBLS

As suggested by the pioneering studies by Zadeh [122] and Xu [56], linguistic variables behave more powerfully in tackling with ill-structured decision making problems. However, complexities in those problems usually outperform linguistic variables and entail additional hybrid complicated characteristics in decision makers' assessments, including decision hesitancy [61], bipolar epistemic notions (membership and nonmembership degrees) [62], differentiated relative importance among hesitant assessments [63,64], etc. As a result, compound expression tools based on linguistic variables to cover specific above-mentioned complicate characteristics have been accumulatively in development recently. With special respect to the decision scenarios where majority rule applies and decision makers are capable of arriving at the most preferred linguistic variable [65], Zhang, Qi, and Liang [66] introduced the powerful compound expression tool of interval-valued dual hesitant fuzzy uncertain unbalanced linguistic set (IVDHF_UUBLS) to simultaneously accommodate uncertain unbalanced linguistic scaling-based approximation, decision hesitancy, and bipolar epistemic notions (membership and nonmembership degrees). Nevertheless, IVDHF_UUBLS overlooked the non-negligible group opinions in the form of probabilistic supportiveness to membership degrees or nonmembership degrees as suggested in Pang, Wang, and Xu [63]. Therefore, in this section, we extend the IVDHF_UUBLS to probabilistic environments, thereby introducing another more powerful compound expression tool of probabilistic dual hesitant fuzzy uncertain unbalanced linguistic set (PDHF_UUBLS), as defined in the following.

Definition 1. *Let* X *be a fixed set and* S *be a finite and continuous unbalanced linguistic label set. Then the probabilistic dual hesitant fuzzy uncertain unbalanced linguistic set (PDHF_UUBLS)* L_p *on* X *is defined as*

$$L_p = \left\{ \left\langle x_i, \widetilde{s}_{\vartheta(x_i)}, h(x_i)|p(x_i), g(x_i)|q(x_i) \right\rangle | x_i \in X \right\},$$

where $\widetilde{s}_{\vartheta(x_i)} = [s_{\alpha_i}, s_{\beta_i}]$ *represents judgment to object* x_i, s_{α_i}, *and* s_{β_i} *are two unbalanced linguistic variables from the predefined unbalanced linguistic label set* S, *which represents judgments of decision makers (or decision units) to an object.* $h(x_i) = \cup_{\mu_{k_i} \in h(x_i)} \{\mu_{k_i}\}$ *and* $g(x_i) = \cup_{\nu_{t_i} \in g(x_i)} \{\nu_{t_i}\}$ *are two sets of some values in [0,1], which respectively denote the two sets of possible membership degrees and non-membership degrees to what the* x_i *belongs to* $\widetilde{s}_{\vartheta(x_i)}$. $p(x_i) = \cup_{p_{k_i} \in p(x_i)} \{p_{k_i}\}$ *and* $q(x_i) = \cup_{q_{t_i} \in q(x_i)} \{q_{t_i}\}$ *are the corresponding complementary probabilistic information to* $h(x_i)$ *and* $g(x_i)$.

Moreover, the above $h(x_i)|p(x_i)$ and $g(x_i)|q(x_i)$ hold the following conditions: μ_{k_i}, $\nu_{t_i} \in [0,1]$, $0 \le \mu_{k_i}^+ + \nu_{t_i}^+ \le 1$, where $\mu_{k_i}^+ = \cup_{\mu_{k_i} \in h(x_i)} \max\{\mu_{k_i}\}$, $\nu_{t_i}^+ = \cup_{\nu_{t_i} \in g(x_i)} \max\{\nu_{t_i}\}$; $p_{k_i}, q_{t_i} \in [0,1]$, $\sum_{k_i=1}^{\#h_i} p_{k_i} \le 1$, $\sum_{t_i=1}^{\#g_i} q_{t_i} \le 1$. The symbols of $\#h_i$ and $\#g_i$ are the total numbers of elements in $h(x_i)|p(x_i)$ and $g(x_i)|q(x_i)$, respectively.

For convenience, when X has only one element, L_p reduces to $lp = (\widetilde{s}_\vartheta, h|p, g|q)$, where $\widetilde{s}_\vartheta = [s_\alpha, s_\beta]$, $h = \{\mu_k\}$ and $g = \{\nu_t\}$, which is called a probabilistic dual hesitant fuzzy uncertain unbalanced linguistic element (PDHF_UUBLE).

Inspired by the principle in the score function and accuracy function introduced by Ju et al. [123], we can define the following score function and accuracy function for our PDHF_UUBLS.

Given a $lp = (\widetilde{s}_\vartheta, h|p, g|q)$, the concept of linguistic hierarchies, i.e., $LH = \cup_t l(t, n(t))$ is used. $l(t, n(t))$ is a linguistic hierarchy with t indicating the level of hierarchy, and $n(t)$ denotes the granularity of the linguistic term set of t. By use of the transformation function designed by Herrera, Herrera-Viedma and Martinez [69], we have $I^- = \frac{1}{n(t_1)-1} \Delta_{t_0}^{-1}\left(TF_{t_0}^{t_1}(\psi(s_\alpha))\right)$, $I^+ = \frac{1}{n(t_1)-1} \Delta_{t_0}^{-1}\left(TF_{t_0}^{t_1}(\psi(s_\beta))\right)$, where t_1 are the corresponding levels of unbalanced linguistic terms s_α and s_β in a specific LH. Then, the score function $E(lp)$ and deviation degree function $\sigma(lp)$ of PDHF_UUBLE can be defined as:

$$E(lp) = \frac{I^- + I^+}{2} \times (\overline{\mu} - \overline{\nu}) = \frac{I^- + I^+}{2} \times \left(\sum_{k=1}^{l_h} \mu_k p_k \Big/ \sum_{k=1}^{l_h} p_k - \sum_{t=1}^{l_g} \nu_t q_t \Big/ \sum_{t=1}^{l_g} q_t \right) \quad (1)$$

$$\sigma(lp) = \frac{I^- + I^+}{2} \times \left(\left(\sum_{k=1}^{l_h} (\mu_k - \overline{\mu})^2 (p_k \Big/ \sum_{k=1}^{l_h} p_k) \right)^{1/2} + \left(\sum_{t=1}^{l_g} (\nu_k - \overline{\nu})^2 (q_t \Big/ \sum_{t=1}^{l_g} q_t) \right)^{1/2} \right) \tag{2}$$

where l_h and l_g are the numbers of values in h and g, respectively. The larger the score $E(lp)$, the smaller the deviation degree $\sigma(lp)$, the greater the PDHF_UUBLE lp.

Then the comparative rules between any two PDHF_UUBLEs of $lp_1 = \left(\widetilde{s}_{\vartheta_1}, h_1|p_1, g_1|q_1\right)$ and $lp_2 = \left(\widetilde{s}_{\vartheta_2}, h_2|p_2, g_2|q_2\right)$ can be described as:

(I) If $E(lp_1) < E(lp_2)$, then $lp_1 \prec lp_2$;
(II) If $E(lp_1) = E(lp_2)$, then
(i) If $\sigma(lp_1) < \sigma(lp_2)$, then $lp_1 \succ lp_2$;
(ii) If $\sigma(lp_1) = \sigma(lp_2)$, then $lp_1 \sim lp_2$.

4. Information Measures for PDHF_UUBLS Based on LCM-Based Extension Mechanism

Similar to other conventional and compound tools for expressing decision hesitancy, the PDHF_UUBLS proposed in this paper still encounters situations where corresponding membership sets or nonmembership sets of two PDHF_UUBLEs for comparison do not match in length of set. The underlying logic of widely adopted methods were straightforward to complement any unmatched set with its maximum, minimum, or medium, respectively, representing the decision attitudes of optimism, pessimism, or neutrality [63,74]. Although it can simplify the processing of unmatched situations, the usage of above methods obviously distorts the original statistical feature values in general application. More importantly under probabilistic environments, the commonly used mechanism to assign zero probability to all newly added values for the purpose of maintaining basic statistical feature value will cause the zero-value phenomena for all added data in each derived utility set which then fed into information measures used by decision-making processes [75–77], thereby causing more apparent information distortion with the increment in the amount of added values. To tackle the potential distortion caused by the above-mentioned widely adopted extension methods, inspired by the least common multiple (LCM) solution, which was recently put forward for the neutrosophic hesitant fuzzy decision making environments [78,79], we here generalize it to probabilistic decision making scenarios so as to propose a LCM-based extension mechanism for our PDHF_UUBLS. In the following, we adopt LCM as the common length for any unmatched membership set or nonmembership set then uniformly allocate original probabilistic values to the multiplied membership or nonmembership degrees, so that fundamental statistical feature values of extended sets can be maintained, and potential information distortion caused by zero-value phenomena can be avoided.

4.1. LCM-Based Extension Mechanism for PDHF_UUBLS

Suppose now we have $A = \left\{ \left\langle x_i, \widetilde{s}_{\vartheta_A}(x_i), h_A(x_i)|p_A(x_i), g_A(x_i)|q_A(x_i) \right\rangle | x_i \in X \right\}$ and $B = \left\{ \left\langle x_i, \widetilde{s}_{\vartheta_B}(x_i), h_B(x_i)|p_B(x_i), g_B(x_i)|q_B(x_i) \right\rangle | x_i \in X \right\}$ as any two PDHF_UUBLSs on X, in which we have $\widetilde{s}_{\vartheta_A}(x_i) = [s_{\alpha_{Ai}}, s_{\beta_{Ai}}]$, $\widetilde{s}_{\vartheta_B}(x_i) = [s_{\alpha_{Bi}}, s_{\beta_{Bi}}]$,$h_A(x_i)|p_A(x_i) = \cup\left\{ \mu_{k_{Ai}} \middle| p_{k_{Ai}} \right\}$, $g_A(x_i)|q_A(x_i) = \cup\left\{ \nu_{t_{Ai}} \middle| q_{t_{Ai}} \right\}$,$h_B(x_i)|p_B(x_i) = \cup\left\{ \mu_{k_{Bi}} \middle| p_{k_{Bi}} \right\}$, $g_B(x_i)|q_B(x_i) = \cup\left\{ \nu_{t_{Bi}} \middle| q_{t_{Bi}} \right\}$. $h_A(x_i), g_A(x_i), h_B(x_i), g_B(x_i)$ hold conditions: $\mu_{k_{Ai}}, \nu_{t_{Ai}}, \mu_{k_{Bi}}, \nu_{t_{Bi}} \in [0,1], 0 \le \mu^+_{k_{Ai}} + \nu^+_{t_{Ai}} \le 1$, $0 \le \mu^+_{k_{Bi}} + \nu^+_{t_{Bi}} \le 1$ where $\mu^+_{k_{Ai}} = \cup\max\{\mu_{k_{Ai}}\}$, $\nu^+_{t_{Ai}} = \cup\max\{\nu_{t_{Ai}}\}$, $\mu^+_{k_{Bi}} = \cup\max\{\mu_{k_{Bi}}\}$ and $\nu^+_{t_{Bi}} = \cup\max\{\nu_{t_{Bi}}\}$ for $x_i \in X$. $p_A(x_i), q_A(x_i), p_B(x_i), q_B(x_i)$ hold conditions: $p_{k_{Ai}}, q_{t_{Ai}}, p_{k_{Bi}}, q_{t_{Bi}} \in [0,1]$; $\sum_{k_{Ai}=1}^{l_{h_{Ai}}} p_{k_{Ai}} \le 1$, $\sum_{t_{Ai}=1}^{l_{g_{Ai}}} q_{t_{Ai}} \le 1$, $\sum_{k_{Bi}=1}^{l_{h_{Bi}}} p_{k_{Bi}} \le 1$, $\sum_{t_{Bi}=1}^{l_{g_{Bi}}} q_{t_{Bi}} \le 1$. Let $l_{h_{Ai}}, l_{g_{Ai}}, l_{h_{Bi}}, l_{g_{Bi}}$ denote the lengths of $h_A(x_i)|p_A(x_i)$, $g_A(x_i)|q_A(x_i)$, $h_B(x_i)|p_B(x_i)$, $g_B(x_i)|q_B(x_i)$, respectively. More specifically, $l_{h_{Ai}}, l_{g_{Ai}}, l_{h_{Bi}}, l_{g_{Bi}}$ also indicate the numbers of elements in $h_A(x_i)$, $g_A(x_i)$, $h_B(x_i)$ and $g_B(x_i)$ or in $p_A(x_i)$, $q_A(x_i)$, $p_B(x_i)$, $q_B(x_i)$ respectively. Here, we use l_{h_i} as the least common multiple of $l_{h_{Ai}}$ and $l_{h_{Bi}}$, while use l_{g_i} as the least common multiple of $l_{g_{Ai}}$ and $l_{g_{Bi}}$.

Then we can extend the PDHF_UUBLSs of A and B to A^* and B^*, we have:

$$A^* = \left\{\langle x_i, \widetilde{s}_{\vartheta_A}(x_i), h^*_A(x_i)|p^*_A(x_i), g^*_A(x_i)|q^*_A(x_i)\rangle | x_i \in X\right\},$$

$$B^* = \left\{\langle x_i, \widetilde{s}_{\vartheta_B}(x_i), h^*_B(x_i)|p^*_B(x_i), g^*_B(x_i)|q^*_B(x_i)\rangle | x_i \in X\right\},$$

$$h^*_A(x_i)|p^*_A(x_i) = \cup\left\{\mu^*_{k_{Ai}}\middle|p^*_{k_{Ai}}\right\},\ g^*_A(x_i)|q^*_A(x_i) = \cup\left\{\nu^*_{t_{Ai}}\middle|q^*_{t_{Ai}}\right\},$$

$$h^*_B(x_i)|p^*_B(x_i) = \cup\left\{\mu^*_{k_{Bi}}\middle|p^*_{k_{Bi}}\right\},\ g^*_B(x_i)|q^*_B(x_i) = \cup\left\{\nu^*_{t_{Bi}}\middle|q^*_{t_{Bi}}\right\}.$$

Here we take $h^*_A(x_i)|p^*_A(x_i)$ as an example,

$$h^*_A(x_i)|p^*_A(x_i) = \cup\left\{\mu^*_{k_{Ai}}\middle|p^*_{k_{Ai}}\right\} = \left\{\underbrace{\mu_{1_{Ai}}\middle|\frac{p_{1_{Ai}}}{l^*_{h_{Ai}}}, \ldots, \mu_{1_{Ai}}\middle|\frac{p_{1_{Ai}}}{l^*_{h_{Ai}}}}_{l^*_{h_{Ai}}}, \ldots, \underbrace{\mu_{k_{Ai}}\middle|\frac{p_{k_{Ai}}}{l^*_{h_{Ai}}}, \ldots, \mu_{k_{Ai}}\middle|\frac{p_{k_{Ai}}}{l^*_{h_{Ai}}}}_{l^*_{h_{Ai}}}, \ldots, \underbrace{\mu_{l_{h_{Ai}}}\middle|\frac{p_{l_{h_{Ai}}}}{l^*_{h_{Ai}}}, \ldots, \mu_{l_{h_{Ai}}}\middle|\frac{p_{l_{h_{Ai}}}}{l^*_{h_{Ai}}}}_{l^*_{h_{Ai}}}\right\}.$$

Similarity, we obtain $g^*_A(x_i)|q^*_A(x_i)$, $h^*_B(x_i)|p^*_B(x_i)$ and $g^*_B(x_i)|q^*_B(x_i)$ as follows,

$$g^*_A(x_i)|q^*_A(x_i) = \cup\left\{\nu^*_{t_{Ai}}\middle|q^*_{t_{Ai}}\right\} = \left\{\underbrace{\nu_{1_{Ai}}\middle|\frac{q_{1_{Ai}}}{l^*_{g_{Ai}}}, \ldots, \nu_{1_{Ai}}\middle|\frac{q_{1_{Ai}}}{l^*_{g_{Ai}}}}_{l^*_{g_{Ai}}}, \ldots, \underbrace{\nu_{t_{Ai}}\middle|\frac{q_{t_{Ai}}}{l^*_{g_{Ai}}}, \ldots, \nu_{t_{Ai}}\middle|\frac{q_{t_{Ai}}}{l^*_{g_{Ai}}}}_{l^*_{g_{Ai}}}, \ldots, \underbrace{\nu_{l_{g_{Ai}}}\middle|\frac{q_{l_{g_{Ai}}}}{l^*_{g_{Ai}}}, \ldots, \nu_{l_{g_{Ai}}}\middle|\frac{q_{l_{g_{Ai}}}}{l^*_{g_{Ai}}}}_{l^*_{g_{Ai}}}\right\},$$

$$h^*_B(x_i)|p^*_B(x_i) = \cup\left\{\mu^*_{k_{Bi}}\middle|p^*_{k_{Bi}}\right\} = \left\{\underbrace{\mu_{1_{Bi}}\middle|\frac{p_{1_{Bi}}}{l^*_{h_{Bi}}}, \ldots, \mu_{1_{Bi}}\middle|\frac{p_{1_{Bi}}}{l^*_{h_{Bi}}}}_{l^*_{h_{Bi}}}, \ldots, \underbrace{\mu_{k_{Bi}}\middle|\frac{p_{k_{Bi}}}{l^*_{h_{Bi}}}, \ldots, \mu_{k_{Bi}}\middle|\frac{p_{k_{Bi}}}{l^*_{h_{Bi}}}}_{l^*_{h_{Bi}}}, \ldots, \underbrace{\mu_{l_{h_{Bi}}}\middle|\frac{p_{l_{h_{Bi}}}}{l^*_{h_{Bi}}}, \ldots, \mu_{l_{h_{Bi}}}\middle|\frac{p_{l_{h_{Bi}}}}{l^*_{h_{Bi}}}}_{l^*_{h_{Bi}}}\right\},$$

$$g^*_B(x_i)|q^*_B(x_i) = \cup\left\{\nu^*_{t_{Bi}}\middle|q^*_{t_{Bi}}\right\} = \left\{\underbrace{\nu_{1_{Bi}}\middle|\frac{q_{1_{Bi}}}{l^*_{g_{Bi}}}, \ldots, \nu_{1_{Bi}}\middle|\frac{q_{1_{Bi}}}{l^*_{g_{Bi}}}}_{l^*_{g_{Bi}}}, \ldots, \underbrace{\nu_{t_{Bi}}\middle|\frac{q_{t_{Bi}}}{l^*_{g_{Bi}}}, \ldots, \nu_{t_{Bi}}\middle|\frac{q_{t_{Bi}}}{l^*_{g_{Bi}}}}_{l^*_{g_{Bi}}}, \ldots, \underbrace{\nu_{l_{g_{Bi}}}\middle|\frac{q_{l_{g_{Bi}}}}{l^*_{g_{Bi}}}, \ldots, \nu_{l_{g_{Bi}}}\middle|\frac{q_{l_{g_{Bi}}}}{l^*_{g_{Bi}}}}_{l^*_{g_{Bi}}}\right\},$$

where $l^*_{h_{Ai}} = \frac{l_{h_i}}{l_{h_{Ai}}}$, $l^*_{h_{Bi}} = \frac{l_{h_i}}{l_{h_{Bi}}}$, $l^*_{g_{Ai}} = \frac{l_{g_i}}{l_{g_{Ai}}}$, $l^*_{g_{Bi}} = \frac{l_{g_i}}{l_{g_{Bi}}}$.

Further, given that t_{Ai}, t_{Bi} are corresponding levels of unbalanced linguistic terms $\widetilde{s}_{\vartheta_A}(x_i)$ and $\widetilde{s}_{\vartheta_B}(x_i)$, $I^-_{Ai} = \frac{1}{n(t_{Ai})-1}\Delta^{-1}_{t_0}\left(TF^{t_{Ai}}_{t_0}(\psi(s_{\alpha_{Ai}}))\right)$, $I^+_{Ai} = \frac{1}{n(t_{Ai})-1}\Delta^{-1}_{t_0}\left(TF^{t_{Ai}}_{t_0}(\psi(s_{\beta_{Ai}}))\right)$, $I^-_{Bi} = \frac{1}{n(t_{Bi})-1}\Delta^{-1}_{t_0}\left(TF^{t_{Bi}}_{t_0}(\psi(s_{\alpha_{Bi}}))\right)$, $I^+_{Bi} = \frac{1}{n(t_{Bi})-1}\Delta^{-1}_{t_0}\left(TF^{t_{Bi}}_{t_0}(\psi(s_{\beta_{Bi}}))\right)$ in corresponding LH respectively. According to Equations (1) and (2), we have Theorem 1 described as follows.

Theorem 1. *Suppose* A^* *and* B^* *be the corresponding extended forms of* A *and* B*. Then relationships between them satisfy:*

(1) $l\left(\widetilde{h}^*_A(x_i)\right) = l\left(\widetilde{h}^*_B(x_i)\right)$, $l(\widetilde{g}^*_A(x_i)) = l(\widetilde{g}^*_B(x_i))$;

(2) $E(A^*) = E(A)$, $E(B^*) = E(B)$;

(3) $\sigma(A^*) = \sigma(A)$, $\sigma(B^*) = \sigma(B) \Rightarrow \widetilde{h}_A(x_i) \sim \widetilde{h}^*_A(x_i)$, $\widetilde{g}_A(x_i) \sim \widetilde{g}^*_A(x_i)$, $\widetilde{h}_B(x_i) \sim \widetilde{h}^*_B(x_i)$, $\widetilde{g}_B(x_i) \sim \widetilde{g}^*_B(x_i)$.

Theorem 1 indicates that our proposed LCM-based extension mechanism for PDHF_UUBLS is capable of maintaining consistency of any two PDHF_UUBLEs for comparisons in further operations that required by information measures and host MAGDM approaches.

Now with the support of the above LCM-based extension mechanism, we can put forward some key information measures for PDHF_UUBLS.

4.2. Novel Distance Measures for PDHF_UUBLS

In this section, we propose a more generalized distance measure as shown in Definition 2 and its weighted version in Definition 3. Their desirable properties are verified in Theorem 2.

Definition 2. *Let* A *and* B *be two PDHF_UUBLSs defined on the universe of* $X = \{x_1, x_2, \ldots, x_n\}$, A^* *and* B^* *be the corresponding extended forms of* A *and* B, *then the generalized normalized distance between* A *and* B *can be defined as:*

$$d^{GN}(A,B) = \frac{1}{n}\sum_{i=1}^{n}\left(\frac{1}{2}\left(\left|\frac{I_{Ai}^{-}+I_{Ai}^{+}}{2}-\frac{I_{Bi}^{-}+I_{Bi}^{+}}{2}\right|^{\lambda}+\frac{1}{2}\left(\frac{1}{l_{\tilde{h}_i}}\sum_{k_{Ai},k_{Bi}=1}^{l_{\tilde{h}_i}}\left|\mu_{k_{Ai}}^{*}p_{k_{Ai}}^{*}-\mu_{k_{Bi}}^{*}p_{k_{Bi}}^{*}\right|^{\lambda}+\frac{1}{l_{\tilde{g}_i}}\sum_{t_{Ai},t_{Bi}=1}^{l_{\tilde{g}_i}}\left|\nu_{t_{Ai}}^{*}q_{t_{Ai}}^{*}-\nu_{t_{Bi}}^{*}q_{t_{Bi}}^{*}\right|^{\lambda}\right)\right)\right)^{\frac{1}{\lambda}}. \tag{3}$$

If $\lambda = 1$, *then the above generalized normalized distance between* A *and* B *reduces to the hesitant normalized Hamming distance as*

$$d^{NH}(A,B) = \frac{1}{n}\sum_{i=1}^{n}\frac{1}{2}\left(\left|\frac{I_{Ai}^{-}+I_{Ai}^{+}}{2}-\frac{I_{Bi}^{-}+I_{Bi}^{+}}{2}\right|+\frac{1}{2}\left(\frac{1}{l_{\tilde{h}_i}}\sum_{k_{Ai},k_{Bi}=1}^{l_{\tilde{h}_i}}\left|\mu_{k_{Ai}}^{*}p_{k_{Ai}}^{*}-\mu_{k_{Bi}}^{*}p_{k_{Bi}}^{*}\right|+\frac{1}{l_{\tilde{g}_i}}\sum_{t_{Ai},t_{Bi}=1}^{l_{\tilde{g}_i}}\left|\nu_{t_{Ai}}^{*}q_{t_{Ai}}^{*}-\nu_{t_{Bi}}^{*}q_{t_{Bi}}^{*}\right|\right)\right). \tag{4}$$

If $\lambda = 2$, *then the above generalized normalized distance between* A *and* B *reduces to the hesitant normalized Euclidean distance as*

$$d^{NE}(A,B) = \frac{1}{n}\sum_{i=1}^{n}\left(\frac{1}{2}\left(\left|\frac{I_{Ai}^{-}+I_{Ai}^{+}}{2}-\frac{I_{Bi}^{-}+I_{Bi}^{+}}{2}\right|^{2}+\frac{1}{2}\left(\frac{1}{l_{\tilde{h}_i}}\sum_{k_{Ai},k_{Bi}=1}^{l_{\tilde{h}_i}}\left|\mu_{k_{Ai}}^{*}p_{k_{Ai}}^{*}-\mu_{k_{Bi}}^{*}p_{k_{Bi}}^{*}\right|^{2}+\frac{1}{l_{\tilde{g}_i}}\sum_{t_{Ai},t_{Bi}=1}^{l_{\tilde{g}_i}}\left|\nu_{t_{Ai}}^{*}q_{t_{Ai}}^{*}-\nu_{t_{Bi}}^{*}q_{t_{Bi}}^{*}\right|^{2}\right)\right)\right)^{\frac{1}{2}}. \tag{5}$$

Furthermore, similar to the facts that evaluative attributes often have relative importance to each other, if there is weight information on each dimension of the two PDHF_UUBLSs under comparison, we need to take the weight information into account. Thus in the following Definition 3, we introduce the weighted distance measure between PDHF_UUBLSs. Let $w = \{w_1, w_2, \ldots, w_n\}$ be the weighting vector of $x_i (i = 1, 2, \ldots, n)$ with $w_i \geq 0$ and $\sum_{i=1}^{n} w_i = 1$. Then the weighted generalized normalized distance can be defined as follows.

Definition 3. *Let* A *and* B *be two PDHF_UUBLSs defined on the universe of* $X = \{x_1, x_2, \ldots, x_n\}$, *then the weighted generalized normalized distance between* A *and* B *is defined as:*

$$d^{WGN}(A,B) = \frac{1}{n}\sum_{i=1}^{n}w_i\left(\frac{1}{2}\left(\left|\frac{I_{Ai}^{-}+I_{Ai}^{+}}{2}-\frac{I_{Bi}^{-}+I_{Bi}^{+}}{2}\right|^{\lambda}+\frac{1}{2}\left(\frac{1}{l_{\tilde{h}_i}}\sum_{k_{Ai},k_{Bi}=1}^{l_{\tilde{h}_i}}\left|\mu_{k_{Ai}}^{*}p_{k_{Ai}}^{*}-\mu_{k_{Bi}}^{*}p_{k_{Bi}}^{*}\right|^{\lambda}+\frac{1}{l_{\tilde{g}_i}}\sum_{t_{Ai},t_{Bi}=1}^{l_{\tilde{g}_i}}\left|\nu_{t_{Ai}}^{*}q_{t_{Ai}}^{*}-\nu_{t_{Bi}}^{*}q_{t_{Bi}}^{*}\right|^{\lambda}\right)\right)\right)^{\frac{1}{\lambda}}. \tag{6}$$

Theorem 2. *The distance measure* d *defined in Definition 2 and Definition 3 satisfies following properties:*

(1) $0 \leq d(A,B) \leq 1$;
(2) $d(A,B) = 0$ *if and only if* A *and* B *are perfectly consistent;*
(3) $d(A,B) = d(B,A)$.

4.3. Entropy Measure and Cross Entropy Measure for PDHF_UUBLS

Fuzzy entropy measure provides an effective way to indicate the uncertainty degree and fuzziness of a fuzzy set [124,125]. Various extended versions of fuzzy entropy measures have been successfully developed and play indispensable roles in establishing appropriate and effective uncertain decision making approaches, including [53,126–128], among others. Therefore, in order to facilitate construction of effective decision-making approaches with comprehensive evaluations in the form of PDHF_UUBLS, we further develop some entropy and cross-entropy measures for PDHF_UUBLS.

Definition 4. *Given* $A = \left\{ \langle x_i, \tilde{s}_{\vartheta_A}(x_i), h_A(x_i)|p_A(x_i), g_A(x_i)|q_A(x_i) \rangle | x_i \in X \right\}$ *as a set in the form of PDHF_UUBLS, the fuzzy entropy measure of* A *can be defined as* $E^1(A)$*:*

$$E^1(A) = -\frac{1}{2\ln 2}\sum_{i=1}^{n}\Bigg(I_{Ai}^- \ln I_{Ai}^- + (1 - I_{Ai}^-)\ln(1 - I_{Ai}^-) + I_{Ai}^+ \ln I_{Ai}^+ + (1 - I_{Ai}^+)\ln(1 - I_{Ai}^+) \\ + \sum_{k_{Ai}=1}^{l_{h_{Ai}}} p_{k_{Ai}}\left(\mu_{k_{Ai}} \ln \mu_{k_{Ai}} + (1 - \mu_{k_{Ai}})\ln(1 - \mu_{k_{Ai}})\right) + \sum_{t_{Ai}=1}^{l_{g_{Ai}}} q_{t_{Ai}}\left(\nu_{t_{Ai}} \ln \nu_{t_{Ai}} + (1 - \nu_{t_{Ai}})\ln(1 - \nu_{t_{Ai}})\right)\Bigg) \quad (7)$$

Regarding the above fuzzy entropy measure $E^1(A)$, we have the following fundamental observations as shown in following Theorem 3.

Theorem 3. *The entropy* $E^1(A)$ *on* A *satisfies the following basic requirements:*

(1) $0 \le E^1(A) \le 1$;
(2) $E^1(A) = 0$, *if and only if* $A = \left\{ \langle x_i, ([s_g, s_g], \{1|1\}, \{0|0\}) \rangle | x_i \in X \right\}$ *or* $A = \left\{ \langle x_i, ([s_g, s_g], \{0|0\}, \{1|1\}) \rangle | x_i \in X \right\}$;
(3) $E^1(A) = 1$, *if* $A = \left\{ \left\langle x_i, \left([s_{g/2}, s_{g/2}], \{1|1\}, \{0|0\}\right) \right\rangle | x_i \in X \right\}$;
(4) $E^1(A) \le E^1(B)$ *if* $I_{Ai}^+ \le I_{Bi}^+ \le 0.5$ *or* $I_{Ai}^- \ge I_{Bi}^- \ge 0.5$, *and* $h_A(x_i)|p_A(x_i) = h_B(x_i)|p_B(x_i)$, $g_A(x_i)|q_A(x_i) = g_B(x_i)|q_B(x_i)$, $l_{h_{Ai}} = l_{h_{Bi}}$;
(5) $E^1(A) = E^1(A^c)$, *where* $A^c = \left\{ \langle x_i, 1 - \tilde{s}_{\vartheta_A}(x_i), g_A(x_i)|q_A(x_i), h_A(x_i)|p_A(x_i) \rangle | x_i \in X \right\}$.

Further, by use of the distance measures of PDHF_UUBLS, we also can propose another novel entropy measure $E^2(A)$ for PDHF_UUBLS in the following Definition 5.

Definition 5. *Given* $A = \left\{ \langle x_i, \tilde{s}_{\vartheta_A}(x_i), h_A(x_i)|p_A(x_i), g_A(x_i)|q_A(x_i) \rangle | x_i \in X \right\}$ *as a set in the form of PDHF_UUBLS, and let* $A^F = \left\{ \left\langle x_i, \left([s_{g/2}, s_{g/2}], \{1|1\}, \{0|0\}\right) \right\rangle | x_i \in X \right\}$ *denote the corresponding fuzziest PDHF_UUBLS, then based on the distance measures of PDHF_UUBLS, we can define entropy measure* $E^2(A)$ *for PDHF_UUBLS as*

$$E^2(A) = 1 - d(A, A^F), \quad (8)$$

where $d(A, A^F)$ *can be calculated by use of a distance measure selected from* ***Definition 2****.*

Regarding the above fuzzy entropy measure $E^2(A)$, we all also can prove it satisfies the basic requirements listed in Theorem 3, thus omitted here for brevity.

Furthermore, in order to measure information difference between two PDHF_UUBLSs, we here also put forward a cross-entropy measure for our PDHF_UUBLSs, as described in the following Definition 6.

Definition 6. *Let* A *and* B *be any two PDHF_UUBLSs,* A^* *and* B^* *are the extended forms of* A *and* B *transformed by LCM-based extension mechanism introduced in Section 4.1, then cross entropy measure* $CE(A, B)$ *between* A *and* B *can be defined as:*

$$
\begin{aligned}
&CE(A,B) = CE(A^*,B^*) \\
&= \frac{1}{T}\sum_{i=1}^{T}\Bigg(\left(\frac{(1+q(I^-_{Ai}))\ln(1+q(I^-_{Ai}))+(1+q(I^-_{Bi}))\ln(1+q(I^-_{Bi}))}{2} - \frac{2+q(I^-_{Ai})+q(I^-_{Bi})}{2}\ln\frac{2+q(I^-_{Ai})+q(I^-_{Bi})}{2}\right)+ \\
&\left(\frac{(1+q(I^+_{Ai}))\ln(1+q(I^+_{Ai}))+(1+q(I^+_{Bi}))\ln(1+q(I^+_{Bi}))}{2} - \frac{2+q(I^+_{Ai})+q(I^+_{Bi})}{2}\ln\frac{2+q(I^+_{Ai})+q(I^+_{Bi})}{2}\right) \\
&+\frac{1}{l_{h_i}}\sum_{k_A=1,k_B=1}^{l_{h_i}}\left(\frac{(1+q(\mu^*_{k_{Ai}}p^*_{k_{Ai}}))\ln(1+q(\mu^*_{k_{Ai}}p^*_{k_{Ai}}))+(1+q(\mu^*_{k_{Bi}}p^*_{k_{Bi}}))\ln(1+q(\mu^*_{k_{Bi}}p^*_{k_{Bi}}))}{2}\right. \\
&\left.-\frac{2+q(\mu^*_{k_{Ai}}p^*_{k_{Ai}})+q(\mu^*_{k_{Bi}}p^*_{k_{Bi}})}{2}\ln\frac{2+q(\mu^*_{k_{Ai}}p^*_{k_{Ai}})+q(\mu^*_{k_{Bi}}p^*_{k_{Bi}})}{2}\right)+ \\
&\frac{1}{l_{g_i}}\sum_{t_A=1,t_B=1}^{l_{g_i}}\left(\frac{(1+q(\nu^*_{t_{Ai}}q^*_{t_{Ai}}))\ln(1+q(\nu^*_{t_{Ai}}q^*_{t_{Ai}}))+(1+q(\nu^*_{t_{Bi}}q^*_{t_{Bi}}))\ln(1+q(\nu^*_{t_{Bi}}q^*_{t_{Bi}}))}{2}\right. \\
&\left.-\frac{2+q(\nu^*_{t_{Ai}}q^*_{t_{Ai}})+q(\nu^*_{t_{Bi}}q^*_{t_{Bi}})}{2}\ln\frac{2+q(\nu^*_{t_{Ai}}q^*_{t_{Ai}})+q(\nu^*_{t_{Bi}}q^*_{t_{Bi}})}{2}\right)\Bigg).
\end{aligned} \tag{9}
$$

The above cross-entropy measure $CE(A,B)$ holds the fundamental conditions shown in the following Theorem 4.

Theorem 4. *The cross entropy* $CE(A,B)$ *satisfies the following conditions:*

(1) $CE(A,B) \geq 0$; *(2)* $CE(A,B) = 0$ *when* $\widetilde{s}_{\vartheta_A}(x_i) = \widetilde{s}_{\vartheta_B}(x_i)$, $h_A(x_i) = h_B(x_i)$, $p_A(x_i) = p_B(x_i)$, $g_A(x_i) = g_B(x_i)$ *and* $q_A(x_i) = q_B(x_i)$.

Proof of Theorem 4. (1) According to Shannon's inequality, we have

$$
\begin{aligned}
&-CE(A,B) \\
&= \frac{1}{T}\sum_{i=1}^{T}\Bigg(\left(\frac{(1+q(I^-_{Ai}))\ln\frac{1}{(1+q(I^-_{Ai}))}+(1+q(I^-_{Bi}))\ln\frac{1}{(1+q(I^-_{Bi}))}}{2} - \frac{2+q(I^-_{Ai})+q(I^-_{Bi})}{2}\ln\frac{2}{2+q(I^-_{Ai})+q(I^-_{Bi})}\right) \\
&+\left(\frac{(1+q(I^+_{Ai}))\ln\frac{1}{(1+q(I^+_{Ai}))}+(1+q(I^+_{Bi}))\ln\frac{1}{(1+q(I^+_{Bi}))}}{2} - \frac{2+q(I^+_{Ai})+q(I^+_{Bi})}{2}\ln\frac{2}{2+q(I^+_{Ai})+q(I^+_{Bi})}\right) \\
&+\frac{1}{l_{h_i}}\sum_{k_A=1,k_B=1}^{l_{h_i}}\left(\frac{(1+q(\mu^*_{k_{Ai}}p^*_{k_{Ai}}))\ln\frac{1}{(1+q(\mu^*_{k_{Ai}}p^*_{k_{Ai}}))}+(1+q(\mu^*_{k_{Bi}}p^*_{k_{Bi}}))\ln\frac{1}{(1+q(\mu^*_{k_{Bi}}p^*_{k_{Bi}}))}}{2}\right. \\
&\left.-\frac{2+q(\mu^*_{k_{Ai}}p^*_{k_{Ai}})+q(\mu^*_{k_{Bi}}p^*_{k_{Bi}})}{2}\ln\frac{2}{2+q(\mu^*_{k_{Ai}}p^*_{k_{Ai}})+q(\mu^*_{k_{Bi}}p^*_{k_{Bi}})}\right)+ \\
&\frac{1}{l_{g_i}}\sum_{t_A=1,t_B=1}^{l_{g_i}}\left(\frac{(1+q(\nu^*_{t_{Ai}}q^*_{t_{Ai}}))\ln\frac{1}{(1+q(\nu^*_{t_{Ai}}q^*_{t_{Ai}}))}+(1+q(\nu^*_{t_{Bi}}q^*_{t_{Bi}}))\ln\frac{1}{(1+q(\nu^*_{t_{Bi}}q^*_{t_{Bi}}))}}{2}\right. \\
&\left.-\frac{2+q(\nu^*_{t_{Ai}}q^*_{t_{Ai}})+q(\nu^*_{t_{Bi}}q^*_{t_{Bi}})}{2}\ln\frac{2}{2+q(\nu^*_{t_{Ai}}q^*_{t_{Ai}})+q(\nu^*_{t_{Bi}}q^*_{t_{Bi}})}\right)\Bigg) \leq \\
&\frac{1}{T}\sum_{i=1}^{T}\Bigg(\left(\frac{\ln\frac{(1+q(I^-_{Ai}))}{(1+q(I^-_{Ai}))}+\ln\frac{(1+q(I^-_{Bi}))}{(1+q(I^-_{Bi}))}}{2} - \ln\frac{2+q(I^-_{Ai})+q(I^-_{Bi})}{2}\,\frac{2}{2+q(I^-_{Ai})+q(I^-_{Bi})}\right) \\
&+\left(\frac{\ln\frac{(1+q(I^+_{Ai}))}{(1+q(I^+_{Ai}))}+\ln\frac{(1+q(I^+_{Bi}))}{(1+q(I^+_{Bi}))}}{2} - \ln\frac{2+q(I^+_{Ai})+q(I^+_{Bi})}{2}\,\frac{2}{2+q(I^+_{Ai})+q(I^+_{Bi})}\right) \\
&+\frac{1}{l_{h_i}}\sum_{k_A=1,k_B=1}^{l_{h_i}}\left(\frac{\ln\frac{(1+q(\mu^*_{k_{Ai}}p^*_{k_{Ai}}))}{(1+q(\mu^*_{k_{Ai}}p^*_{k_{Ai}}))}+\ln\frac{(1+q(\mu^*_{k_{Bi}}p^*_{k_{Bi}}))}{(1+q(\mu^*_{k_{Bi}}p^*_{k_{Bi}}))}}{2} - \ln\frac{2+q(\mu^*_{k_{Ai}}p^*_{k_{Ai}})+q(\mu^*_{k_{Bi}}p^*_{k_{Bi}})}{2}\,\frac{2}{2+q(\mu^*_{k_{Ai}}p^*_{k_{Ai}})+q(\mu^*_{k_{Bi}}p^*_{k_{Bi}})}\right)+
\end{aligned}
$$

$$\frac{1}{l_{g_i}}\sum_{t_A=1,t_B=1}^{l_{g_i}}\left(\frac{\ln\frac{(1+q(\nu^*_{t_{Ai}}q^*_{t_{Ai}}))}{(1+q(\nu^*_{t_{Ai}}q^*_{t_{Ai}}))}+\ln\frac{(1+q(\nu^*_{t_{Bi}}q^*_{t_{Bi}}))}{(1+q(\nu^*_{t_{Bi}}q^*_{t_{Bi}}))}}{2}-\ln\frac{2+q(\nu^*_{t_{Ai}}q^*_{t_{Ai}})+q(\nu^*_{t_{Bi}}q^*_{t_{Bi}})}{2}\frac{2}{2+q(\nu^*_{t_{Ai}}q^*_{t_{Ai}})+q(\nu^*_{t_{Bi}}q^*_{t_{Bi}})}\right)\Bigg)\Bigg)$$

$$=\frac{1}{T}\sum_{i=1}^{T}\left(\left(\frac{\ln 1+\ln 1}{2}-\ln 1\right)+\left(\frac{\ln 1+\ln 1}{2}-\ln 1\right)+\frac{1}{l_{h_i}}\sum_{k_A=1,k_B=1}^{l_{h_i}}\left(\frac{\ln 1+\ln 1}{2}-\ln 1\right)+\frac{1}{l_{g_i}}\sum_{t_A=1,t_B=1}^{l_{g_i}}\left(\frac{\ln 1+\ln 1}{2}-\ln 1\right)\right)=0$$

Then, we can obtain $CE(A,B)\geq 0$.

(2) The proofs are relatively simple, thus omitted here for brevity.□

5. Multiple Attributes Group Decision-Making Approach under PDHF_UUBLS Environment

In this section, we focus on construction of effective approach for MAGDM with decision information in the form of PDHF_UUBLS. Let $Ex=\{Ex^1,Ex^2,\ldots,Ex^o\}$ denote a set of decision makers, $A=\{A_1,A_2,\ldots,A_m\}$ represent a set of alternatives under evaluation, $C=\{C_1,C_2,\ldots,C_n\}$ stand for a set of attributes based on which decision makers will comprehensively consider each alternative. We here use $w=\{w_1,w_2,\ldots,w_n\}$ to denote the weighting vector for C and $\eta=\{\eta^1,\eta^2,\ldots,\eta^o\}$ to denote the weighting vector for Ex. w holds the conditions of $w_i\geq 0,\sum_{i=1}^{n}w_i=1$ and η holds the conditions of $\eta_j\geq 0,\sum_{j=1}^{o}\eta^j=1$. Then, we use $R^\kappa=\left(r^\kappa_{ij}\right)_{n\times m}$ to represent the individual decision matrix provided by decision maker Ex^κ with his/her assessments regarding alternatives $A_j(j=1\ldots m)$ under all attributes $C_i(i=1\ldots n)$ in the form of PDHF_UUBLS, where $r^\kappa_{ij}=\left(\tilde{s}^\kappa_{ij},h^\kappa_{ij}\middle|p^\kappa_{ij},g^\kappa_{ij}\middle|q^\kappa_{ij}\right)$ and $\tilde{s}^\kappa_{ij}=[s^\kappa_{\alpha_{ij}},s^\kappa_{\beta_{ij}}]$, $h^\kappa_{ij}=\cup\{\mu^\kappa_{ij}\}$, $g^\kappa_{ij}=\cup\{\nu^\kappa_{ij}\}$. It is important to be pointed out that with a high degree of complexity in certain comprehensive evaluation problems both w and η usually cannot be obtained in advance, that is, both are unknown. Therefore, in the following, we firstly devise programming models to rationally obtain unknown weighting vectors, and then construct an effective MAGDM approach based on formerly discussed methods.

5.1. Programming Model for Obtaining Attributes' Weighting Vector

Suppose that all assessments in the form of PDHF_UUBLS by κth decision maker or decision unit have been collected in the decision matrix of $R^\kappa=\left(r^\kappa_{ij}\right)_{n\times m}$. In addition, based on former knowledge and experience, the κth decision maker or decision will generally have minimum acceptable values and maximal expectation values for each attribute, thereby deriving corresponding positive ideal target $A^{\kappa+}$ and negative ideal target $A^{\kappa-}$:

$$\begin{aligned}A^{\kappa+}&=\{r^{\kappa+}_1,\ldots,r^{\kappa+}_i,\ldots,r^{\kappa+}_n\}\\&=\{(\tilde{s}^{\kappa+}_1,h^{\kappa+}_1|p^{\kappa+}_1,g^{\kappa+}_1|q^{\kappa+}_1),\ldots,(\tilde{s}^{\kappa+}_i,h^{\kappa+}_i|p^{\kappa+}_i,g^{\kappa+}_i|q^{\kappa+}_i),\ldots,(\tilde{s}^{\kappa+}_n,h^{\kappa+}_n|p^{\kappa+}_n,g^{\kappa+}_n|q^{\kappa+}_n)\}\\A^{\kappa-}&=\{r^{\kappa-}_1,\ldots,r^{\kappa-}_i,\ldots,r^{\kappa-}_n\}\\&=\{(\tilde{s}^{\kappa-}_1,h^{\kappa-}_1|p^{\kappa-}_1,g^{\kappa-}_1|q^{\kappa-}_1),\ldots,(\tilde{s}^{\kappa-}_i,h^{\kappa-}_i|p^{\kappa-}_i,g^{\kappa-}_i|q^{\kappa-}_i),\ldots,(\tilde{s}^{\kappa-}_n,h^{\kappa-}_n|p^{\kappa-}_n,g^{\kappa-}_n|q^{\kappa-}_n)\}\end{aligned}$$

Now, in alignment with the seminal principles from widely-used TOPSIS method [129–131], we can obtain distance ratio Ind^κ_{ij} between κth decision matrix $R^\kappa=\left(r^\kappa_{ij}\right)_{n\times m}$ and the above ideal targets according to

$$Ind^\kappa_{ij}=\frac{d(r^\kappa_{ij},r^{\kappa-}_i)}{d(r^\kappa_{ij},r^{\kappa+}_i)},\tag{10}$$

where $d(r_{ij}^{\kappa}, r_i^{\kappa-})$ and $d(r_{ij}^{\kappa}, r_i^{\kappa+})$ are distance measures introduced in Definition 2. Additionally, the optimal weighting vector w^{κ} should maximize the total amount of all weighted Ind_{ij}^{κ}, and a programming model (M-1) can thus be constructed to obtain optimal weighting vector according to each decision matrix as follows,

$$(M-1): \begin{cases} \max F(w^{\kappa}) = \sum\limits_{i=1}^{n}\sum\limits_{j=1}^{m} Ind_{ij}^{\kappa} w_i^{\kappa} \\ s.t. \sum_{i=1}^{n} (w_i^{\kappa})^2 = 1, w_i^{\kappa} \geq 0, i = 1,2,\ldots,n, \kappa = 1,2,\ldots,o \end{cases}.$$

Regarding the solution to above model (M-1), we have the following Theorem 5.

Theorem 5. *The optimal solution to model (M-1) is*

$$w_i^{\kappa} = \frac{\sum_{j=1}^{m} Ind_{ij}^{\kappa}}{\sum_{i=1}^{n}\sum_{j=1}^{m} Ind_{ij}^{\kappa}} (j = 1,2,\ldots,m; i = 1,2,\ldots,n; \kappa = 1,2,\ldots,o). \quad (11)$$

Proof of Theorem 5. To solve the programming model (M-1), we here can apply the Lagrange Multiplier Method to derive its optimal solution.

Firstly, the following Lagrange function is constructed as following

$$L(w_i^{\kappa}, \zeta) = \sum_{i=1}^{n}\sum_{j=1}^{m} Ind_{ij}^{\kappa} w_i^{\kappa} + \frac{\zeta}{2}\left(\sum_{i=1}^{n} (w_i^{\kappa})^2 - 1\right). \quad (12)$$

where ζ is the Lagrange multiplier. Take the first-order derivative on w_i^{κ} and ζ, then set these partial derivatives equal to zero, we have

$$\begin{cases} \frac{\partial L}{\partial w_i^{\kappa}} = \sum_{i=1}^{n}\sum_{j=1}^{m} Ind_{ij}^{\kappa} + \zeta w_i^{\kappa} = 0 \\ \frac{\partial L}{\partial \zeta} = \sum_{i=1}^{n} (w_i^{\kappa})^2 - 1 = 0 \end{cases}.$$

By solving the above equations, we obtain a simple and exact formula for calculating the attribute's weight:

$$w_i^{\kappa*} = \frac{\sum_{j=1}^{m} Ind_{ij}^{\kappa}}{\sqrt{\sum_{i=1}^{n}\left(\sum_{j=1}^{m} Ind_{ij}^{\kappa}\right)^2}}. \quad (13)$$

Then, through normalization, we attain the optimal solution as shown in Equation (11).□

5.2. A Hybrid Method for Deriving Decision Makers' Unknown Weighting Vector

Due to the common difficulties in reasonably assigning subjective weights to decision makers or decision units, domain studies have been advocating appropriate models to objectively determine decision makers' unknown weighting vector, especially under uncertain decision settings [53,66,132]. The entropy measures and cross entropy measures defined in Section 4 for PDHF_UUBLS provide two fundamental ways to deduce relative importance among decision makers [53]: (1) Entropy measure for PDHF_UUBLS is capable of indicating overall fuzziness degree of each decision maker's decision matrix. Decision maker with less fuzziness degree of his/her decision matrix should be allocated with bigger weight. (2) Cross entropy measure for PDHF_UUBLS is capable of indicating the information divergence between any two PDHF_UUBLS decision matrices. According to the widely adopted deviation maximizing methodology, the smaller the divergence between a specific decision maker's decision matrix and those matrices by others, the closer the overall opinion of the decision maker to the collective one, a larger weight thus should be given to him/her.

Therefore, we here first apply the entropy measure $E(A)$ defined in Section 4.3 to indicate fuzziness degree of each decision matrix R^{κ}. Then, we can obtain entropy-based weighting vector $\widetilde{\eta}^{\kappa}(\kappa = 1, 2, \ldots, o)$ for decision makers by utilizing the following formula:

$$\widetilde{\eta}^{\kappa} = \frac{\sum_{j=1}^{m} \sum_{i=1}^{n} \left(1 - E(r_{ij}^{\kappa})\right)}{\sum_{\kappa=1}^{o} \sum_{j=1}^{m} \sum_{i=1}^{n} \left(1 - E(r_{ij}^{\kappa})\right)}. \tag{14}$$

Secondly, we take the cross-entropy measure $CE(R^{\kappa}, R^{\gamma})$ in Section 4.3 to compute overall divergence degree between decision matrix R^{κ} (given by the κth decision maker) and matrices R^{γ} (given by the other decision makers, i.e., $\gamma = 1 \ldots o, \gamma \neq \kappa$). Then, we put forward another method to derive the cross entropy-based weighting vector $\overline{\eta}^{\kappa}(\kappa = 1, 2, \ldots, o)$ for decision makers, that is, the following programming model (M-2):

$$(M-2): \begin{cases} \max F(\overline{\eta}^{\kappa}) = \sum\limits_{\kappa=1}^{o} \frac{1}{o} \left(\sum\limits_{\gamma=1, \gamma \neq \kappa}^{o} (1 - CE(R^{\kappa}, R^{\gamma})) \overline{\eta}^{\kappa} \right) \\ s.t. \sum_{\kappa=1}^{o} (\overline{\eta}^{\kappa})^2 = 1, \overline{\eta}^{\kappa} \geq 0, \kappa = 1, 2, \ldots, o \end{cases},$$

where $CE(R^{\kappa}, R^{\gamma}) = \frac{1}{mn} \sum_{j=1}^{m} \sum_{i=1}^{n} CE(r_{ij}^{\kappa}, r_{ij}^{\gamma})$, $CE(r_{ij}^{\kappa}, r_{ij}^{\gamma})$ are calculated by Equation (9).

Regarding the model (M-2), we have following Theorem 6.

Theorem 6. *The optimal solution to (M-2) is:*

$$\overline{\eta}^{\kappa} = \frac{\sum_{\gamma=1, \gamma \neq \kappa}^{o} \left(1 - \frac{1}{mn} \sum_{j=1}^{m} \sum_{i=1}^{n} CE(r_{ij}^{\kappa}, r_{ij}^{\gamma})\right)}{\sum_{\kappa=1}^{o} \sum_{\gamma=1, \gamma \neq \kappa}^{o} \left(1 - \frac{1}{mn} \sum_{j=1}^{m} \sum_{i=1}^{n} CE(r_{ij}^{\kappa}, r_{ij}^{\gamma})\right)}. \tag{15}$$

Proof of Theorem 6. To solve the model (M-2), we firstly construct the Lagrange function as follows:

$$L(\overline{\lambda}^{\kappa}, \varsigma) = \sum_{\kappa=1}^{o} \frac{1}{t} \left(\sum_{\gamma=1, \gamma \neq \kappa}^{o} \left(1 - \frac{1}{mn} \sum_{j=1}^{m} \sum_{i=1}^{n} CE(r_{ij}^{\kappa}, r_{ij}^{\gamma}) \right) \right) \overline{\lambda}^{\kappa} + \frac{1}{2} \varsigma \sum_{\kappa=1}^{o} \left((\overline{\lambda}^{\kappa})^2 - 1 \right). \tag{16}$$

By deriving differentiation on Equation (16) with respect to $\widetilde{\eta}^{\kappa}(\kappa = 1, 2, \ldots, o)$ and ς, then setting these partial derivatives equal to zero, the following set of equations is obtained:

$$\begin{cases} \frac{\partial L}{\partial \overline{\eta}^{\kappa}} = \frac{1}{t} \left(\sum_{\gamma=1, \gamma \neq \kappa}^{o} \left(1 - \frac{1}{mn} \sum_{j=1}^{m} \sum_{i=1}^{n} CE(r_{ij}^{\kappa}, r_{ij}^{\gamma}) \right) \right) + \varsigma \sum_{\kappa=1}^{o} \overline{\lambda}^{\kappa} = 0 \\ \frac{\partial L}{\partial \varsigma} = \sum_{\kappa=1}^{o} \left((\overline{\lambda}^{\kappa})^2 - 1 \right) = 0 \end{cases}. \tag{17}$$

By solving Equation (17), we can get a simple and exact formula for determining the weighting vector for decision makers, as follows:

$$\overline{\lambda}^{\kappa} = \frac{\frac{1}{t} \left(\sum_{\gamma=1, \gamma \neq \kappa}^{o} \left(1 - \frac{1}{mn} \sum_{j=1}^{m} \sum_{i=1}^{n} CE(r_{ij}^{\kappa}, r_{ij}^{\gamma}) \right) \right)}{\sqrt{\sum_{\kappa=1}^{o} \left(\frac{1}{t} \left(\sum_{\gamma=1, \gamma \neq \kappa}^{o} \left(1 - \frac{1}{mn} \sum_{j=1}^{m} \sum_{i=1}^{n} CE(r_{ij}^{\kappa}, r_{ij}^{\gamma}) \right) \right) \right)^2}}. \tag{18}$$

Then, through normalization, we have the optimal solution shown in Equation (15).□

Now, to simultaneously consider the two objective weighting vectors obtained in Equations (14) and (15), the following hybrid model is generally adopted:

$$\eta^{\kappa} = \alpha \widetilde{\eta}^{\kappa} + \beta \overline{\eta}^{\kappa} (\kappa = 1, 2, \ldots, o), \tag{19}$$

where α and $\beta, 0 \leq \alpha,\ \beta \leq 1,\ \alpha + \beta = 1$, are attitudinal parameters and their configurations are subject to decision organizations. Literatures normally suggest $\alpha = \beta = 0.5$ [53].

5.3. MAGDM Approach under PDHF_UUBLS Environment

Based on the strength of above-developed methods, we now can construct the following **Approach 1** for MAGDM under PDHF_UUBLS environment with unknown weighting vectors for both evaluative attributes and decision makers.

Approach 1. *MAGDM under PDHF_UUBLS environment with unknown weighting vectors for both attributes and decision makers*

Step 1. Invite all decision makers to elaborate their positive ideal alternatives $A^{\kappa+}(\kappa = 1, 2, \ldots, o)$ and negative ideal alternatives $A^{\kappa-}$ $(\kappa = 1, 2, \ldots, o)$, which are denoted in the form of

$$\begin{aligned} A^{\kappa+} &= \{r_1^{\kappa+}, \ldots, r_i^{\kappa+}, \ldots, r_n^{\kappa+}\} \\ &= \{(\tilde{s}_1^{\kappa+}, h_1^{\kappa+}|p_1^{\kappa+}, g_1^{\kappa+}|q_1^{\kappa+}), \ldots, (\tilde{s}_i^{\kappa+}, h_i^{\kappa+}|p_i^{\kappa+}, g_i^{\kappa+}|q_i^{\kappa+}), \ldots, (\tilde{s}_n^{\kappa+}, h_n^{\kappa+}|p_n^{\kappa+}, g_n^{\kappa+}|q_n^{\kappa+})\} \end{aligned}$$

and

$$\begin{aligned} A^{\kappa-} &= \{r_1^{\kappa-}, \ldots, r_i^{\kappa-}, \ldots, r_n^{\kappa-}\} \\ &= \{(\tilde{s}_1^{\kappa-}, h_1^{\kappa-}|p_1^{\kappa-}, g_1^{\kappa-}|q_1^{\kappa-}), \ldots, (\tilde{s}_i^{\kappa-}, h_i^{\kappa-}|p_i^{\kappa-}, g_i^{\kappa-}|q_i^{\kappa-}), \ldots, (\tilde{s}_n^{\kappa-}, h_n^{\kappa-}|p_n^{\kappa-}, g_n^{\kappa-}|q_n^{\kappa-})\} \end{aligned}$$

Step 2. Objectively calculate the weighting vector of $w^{\kappa} = (w_1^{\kappa}, w_2^{\kappa}, \ldots, w_n^{\kappa})$ $(\kappa = 1, 2, \ldots, o)$ for evaluative attributes based on each decision matrix according to programming model (M-1);

Step 3. Objectively compute the weighting vector of $\eta^{\kappa}(\kappa = 1, 2, \ldots, o)$ for decision makers according to Equation(19);

Step 4. Obtain κth decision-maker's comprehensive decision results on each alternatives under evaluation. By utilizing the weighting vectors $w^{\kappa} = (w_1^{\kappa}, w_2^{\kappa}, \ldots, w_n^{\kappa})$ $(\kappa = 1, 2, \ldots, o)$ obtained in **Step 2** and the following **PDHFUUBLWA** operator, we can aggregate r_{ij}^{κ} to get the κth decision-maker's decision results r_j^{κ} on the alternative A_j, where

$$\begin{aligned} r_j^{\kappa} = \left(\tilde{s}_j^{\kappa}, h_j^{\kappa}\middle|p_j^{\kappa}, g_j^{\kappa}\middle|q_j^{\kappa}\right) = \mathrm{PDHFUUBLWA}(r_{1j}^{\kappa}, r_{2j}^{\kappa}, \ldots, r_{nj}^{\kappa}) = \bigoplus_{i=1}^{n}\left(w_i^{\kappa} r_{ij}^{\kappa}\right) \\ \cup_{(\tilde{s}_{ij}^{\kappa}, h_{ij}^{\kappa}|p_{ij}^{\kappa}, g_{ij}^{\kappa}|q_{ij}^{\kappa}) \in r_{ij}^{\kappa}} \left(\left[s_{\sum_{i=1}^{n} w_i^{\kappa} \Delta_{t_0}^{-1}(TF_{t_0}^{t_{ij}}(\psi(s_{\alpha_{ij}}^{\kappa})))}, s_{\sum_{i=1}^{n} w_i^{\kappa} \Delta_{t_0}^{-1}(TF_{t_0}^{t_{ij}}(\psi(s_{\beta_{ij}}^{\kappa})))}\right],\right. \\ \left.\left\{1 - \prod_{i=1}^{n}\left(1 - \mu_{ij}^{\kappa}\right)^{w_i^{\kappa}} \middle| \prod_{i=1}^{n} \frac{p_{ijl_{ij\kappa}}^{\kappa}}{\sum_{l_{ij\kappa}=1}^{L_{ij\kappa}} p_{ijl_{ij\kappa}}^{\kappa}}\right\}, \left\{\prod_{i=1}^{n}\left(\nu_{ij}^{\kappa}\right)^{w_i^{\kappa}} \middle| \prod_{i=1}^{n} \frac{q_{ijl_{ij\kappa}}^{\kappa}}{\sum_{l_{ij\kappa}=1}^{L_{ij\kappa}} q_{ijl_{ij\kappa}}^{\kappa}}\right\}\right). \end{aligned}$$

The above **PDHFUUBLWA** operator is the extended version of conventional weighted arithmetic aggregator [66] to decision making under our PDHF_UUBLS environment. For more details about aggregation operators, one can refer to [133–135].

Step 5. Obtain collective results of all alternatives by applying decision makers' weighting vector. Giving the decision makers' weighting vector $\eta = \{\eta^1, \eta^2, \ldots, \eta^o\}$, which has been determined in **Step 3**, we now can aggregate all the individual overall decision results r_j^{κ} $(\kappa = 1, 2, \ldots, o)$ from **Step 4** into the overall group decision results r_j $(j = 1, 2, \ldots, m)$ by use of the same **PDHFUUBLWA** operator as used in **Step 4**, where

$$r_j = \left(\tilde{s}_j, h_j \middle| p_j, g_j \middle| q_j\right) = \mathrm{PDHFUUBLWA}(r_j^1, r_j^2, \ldots, r_j^{\kappa}) = \mathop{\oplus}_{\kappa=1}^{o}\left(\eta^{\kappa} r_j^{\kappa}\right)$$

$$\bigcup_{(\tilde{s}_j^{\kappa}, h_j^{\kappa}|p_j^{\kappa}, g_j^{\kappa}|q_j^{\kappa}) \in r_j^{\kappa}} \left(\left[s_{\sum_{\kappa=1}^{o} \eta^{\kappa} \Delta_{t_0}^{-1}(TF_{t_0}^{t_j}(\psi(s_{\alpha_j}^{\kappa})))}, s_{\sum_{\kappa=1}^{o} \eta^{\kappa} \Delta_{t_0}^{-1}(TF_{t_0}^{t_j}(\psi(s_{\beta_j}^{\kappa})))} \right], \right.$$

$$\left. \left\{ 1 - \prod_{\kappa=1}^{o} \left(1 - \mu_j^{\kappa}\right)^{\eta^{\kappa}} \middle| \prod_{\kappa=1}^{o} \frac{p_{jl_{j\kappa}}^{\kappa}}{\sum_{l_{j\kappa}=1}^{L_{j\kappa}} p_{jl_{j\kappa}}^{\kappa}} \right\}, \left\{ \prod_{\kappa=1}^{o} \left(\nu_{ij}^{\kappa}\right)^{\eta^{\kappa}} \middle| \prod_{\kappa=1}^{o} \frac{q_{jl_{j\kappa}}^{\kappa}}{\sum_{l_{j\kappa}=1}^{L_{j\kappa}} q_{jl_{j\kappa}}^{\kappa}} \right\} \right).$$

Step 6. According to Equations (1) and (2), calculate $E(r_j)$ and $\sigma(r_j)$ of the group overall assessments r_j $(j = 1, 2, \ldots, m)$ to determine the final ranking order of all the alternatives A_j $(j = 1, 2, \ldots, m)$.

For more clarity, the processing steps of the **Approach 1** have been demonstrated in following Figure 3.

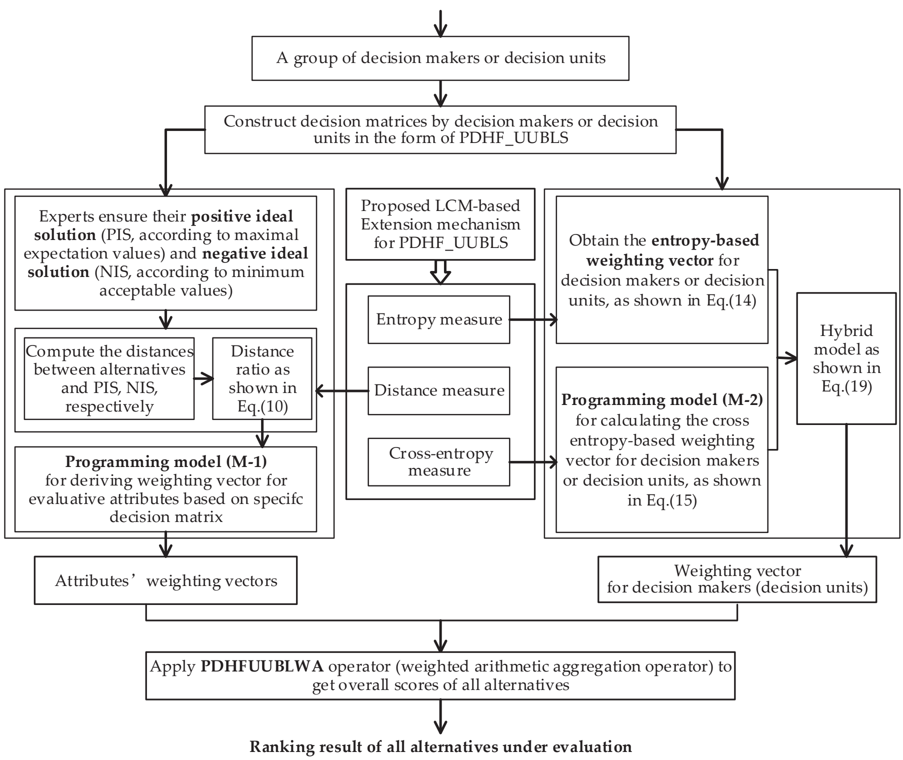

Figure 3. Flowchart of Approach 1 for MAGDM under PDHF_UUBLS environment.

6. Illustrative Example

With regard to the formalized task of comprehensive evaluation of tourism community resilience (as shown in Figure 1), in this section, the Approach 1 constructed in Section 5.3 has been applied to illustrate its effectiveness. Due to the complexity and ill-structured property of the special type problem as shown in Figure 1, the local NGO (or local government) has invited three groups of domain experts as three decision units, $Ex^{\kappa}(\kappa = 1, 2, 3)$, to partake the task in order to attain authoritativeness and authenticity. There are totally four

CBT destinations, $A = \{A_1, A_2, A_3, A_4\}$, under its administration of the NGO (or local government). According to Table 1, the derived six attributes, $C = \{C_1, C_2, C_3, C_4, C_5, C_6\}$, are adopted to evaluate the status quo of tourism community resilience in the four destinations.

The three decision units $Ex^{\kappa}(\kappa = 1, 2, 3)$ have been empowered with the expression tool of our proposed PDHF_UUBLS in elicitation of their collective complicate assessments. It should be noted that all three decision units have the right to choose proper unbalanced linguistic scales, that is, different unbalanced linguistic term sets (ULTSs) [69], according to their preferences. Suppose that decision unit Ex^2 preferred the ULTS of S_1 = {N,AN,VL,QL,L,M, H,QH,VH,AT,T}, while decision unit Ex^1 and decision unit Ex^3 adopted the ULTS of S_2 = {N,VL,L,AL,AM,M,QM,AH,H,VH,T}. The relationship between ULTSs of S_1 and S_2 in the form of linguistic hierarchy is shown in Figure 4. Similar to Section 3, more details about transformation function and operational laws for various unbalanced linguistic term sets in a linguistic hierarchy can be referred to [69] and [66]. Then assessments of three decision units were collected in three decision matrices of $R^{\kappa} = \left(r_{ij}^{\kappa}\right)_{6\times4}$ $(\kappa = 1, 2, 3)$ in the form of PDHF_UUBLS, as shown in Tables 2–4.

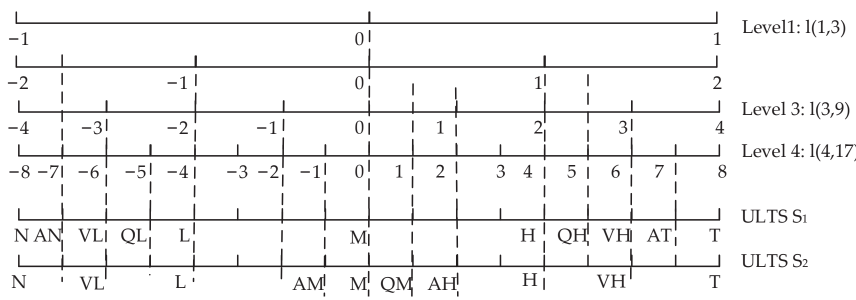

Figure 4. ULTSs of S_1, S_2 and their mapping relations in linguistic hierarchy.

Table 2. Decision matrix R^1 provided by decision unit Ex^1.

Ex^1	A_1	A_2	A_3	A_4
C_1	([QM,H], {0.5 | 0.9}, {0.4 | 0.6, 0.5 | 0.4})	([AH,VH], {0.5 | 0.4,0.6 | 0.6}, {0.4 | 1})	([AM,H], {0.7 | 0.8, 0.8 | 0.2}, {0.2 | 1})	([H,T], {0.6 | 0.2,0.7 | 0.8}, {0.1 | 0.7,0.3 | 0.3})
C_2	([AH,VH], {0.5 | 0.3,0.6 | 0.7}, {0.3 | 0.8})	([VH,T], {0.6 | 1}, {0.2 | 0.5,0.4 | 0.5})	([AH,H], {0.8 | 0.4,0.9 | 0.6}, {0.1 | 0.9})	([VH,T], {0.7 | 1}, {0.1 | 0.6,0.2 | 0.4})
C_3	([H,VH], {0.2 | 0.5,0.4 | 0.4}, {0.4 | 0.5,0.6 | 0.5})	([VL,AL], {0.5 | 0.8,0.7 | 0.2}, {0.3 | 0.9})	([AH,T], {0.7 | 0.9,0.8 | 0.1}, {0.2 | 1})	([H,VH], {0.4 | 0.2,0.6 | 0.7}, {0.3 | 0.6,0.4 | 0.4})
C_4	([AM,QM], {0.7 | 1}, {0.1 | 0.3,0.3 | 0.6})	([H,VH], {0.3 | 0.7,0.4 | 0.2}, {0.6 | 0.9})	([QM,AH], {0.4 | 0.5,0.7 | 0.5}, {0.2 | 0.5,0.3 | 0.5})	([QM,H], {0.6 | 0.1,0.8 | 0.9}, {0.1 | 0.5,0.2 | 0.5})
C_5	([L,AL], {0.5 | 0.5,0.6 | 0.5}, {0.3 | 0.7})	([QM,AH], {0.3 | 0.6,0.5 | 0.3}, {0.1 | 0.4,0.3 | 0.6})	([VH,T], {0.6 | 1}, {0.2 | 0.1,0.3 | 0.7,0.4 | 0.2})	([QM,VH], {0.4 | 0.9}, {0.4 | 0.8,0.6 | 0.2})
C_6	([M,H], {0.9 | 1}, {0.1 | 1})	([M,AH], {0.4 | 1}, {0.5 | 0.5,0.6 | 0.5})	([H,VH], {0.5 | 0.7,0.6 | 0.3}, {0.3 | 0.8,0.4 | 0.1})	([VH,T], {0.6 | 0.3,0.7 | 0.2,0.8 | 0.5}, {0.2 | 1})

Table 3. Decision matrix R^2 provided by decision unit Ex^2.

Ex^2	A_1	A_2	A_3	A_4
C_1	([H,QH], {0.4 ∣ 0.7}, {0.5 ∣ 0.8})	([QH,T], {0.2 ∣ 0.6,0.3 ∣ 0.4}, {0.5 ∣ 0.5,0.7 ∣ 0.5})	([L,M], {0.4 ∣ 0.8,0.6 ∣ 0.1}, {0.2 ∣ 0.3,0.4 ∣ 0.6})	([QH,AT], {0.6 ∣ 0.3,0.8 ∣ 0.7}, {0.1 ∣ 0.5,0.2 ∣ 0.5})
C_2	([QL,L], {0.1 ∣ 0.2,0.3 ∣ 0.8}, {0.7 ∣ 1})	([L,M], {0.6 ∣ 0.7,0.7 ∣ 0.2}, {0.3 ∣ 0.9})	([QH,AT], {0.4 ∣ 0.3,0.7 ∣ 0.5}, {0.3 ∣ 0.6})	([QH,VH], {0.7 ∣ 1}, {0.1 ∣ 0.8,0.3 ∣ 0.1})
C_3	([QH,VH], {0.6 ∣ 0.9,0.7 ∣ 0.1}, {0.1 ∣ 0.1,0.2 ∣ 0.8,0.3 ∣ 0.1})	([AT,T], {0.4 ∣ 0.6,0.5 ∣ 0.3}, {0.3 ∣ 0.8,0.4 ∣ 0.2})	([H,QH], {0.7 ∣ 0.1,0.8 ∣ 0.9}, {0.1 ∣ 0.5,0.2 ∣ 0.5})	([AT,T], {0.6 ∣ 0.5,0.7 ∣ 0.4}, {0.1 ∣ 0.8,0.2 ∣ 0.1,0.3 ∣ 0.1})
C_4	([AN,L], {0.3 ∣ 0.6,0.5 ∣ 0.2}, {0.4 ∣ 0.4,0.5 ∣ 0.6})	([H,VH], {0.5 ∣ 0.2,0.6 ∣ 0.7}, {0.4 ∣ 1})	([VH,T], {0.5 ∣ 0.6,0.8 ∣ 0.4}, {0.1 ∣ 0.8})	([VH,AT], {0.8 ∣ 0.9}, {0.2 ∣ 1})
C_5	([H,AT], {0.4 ∣ 0.2,0.7 ∣ 0.7}, {0.2 ∣ 0.5,0.3 ∣ 0.5})	([H,QH], {0.2 ∣ 0.2,0.3 ∣ 0.8}, {0.5 ∣ 0.6,0.6 ∣ 0.1,0.7 ∣ 0.3})	([M,H], {0.9 ∣ 1}, {0.1 ∣ 1})	([H,VH], {0.5 ∣ 0.7,0.7 ∣ 0.1}, {0.2 ∣ 0.6,0.3 ∣ 0.4})
C_6	([VL,M], {0.6 ∣ 0.2,0.7 ∣ 0.2,0.8 ∣ 0.6}, {0.1 ∣ 0.1,0.2 ∣ 0.7})	([M,H], {0.5 ∣ 0.1,0.7 ∣ 0.9}, {0.3 ∣ 1})	([H,VH], {0.7 ∣ 0.9}, {0.1 ∣ 0.2,0.3 ∣ 0.8})	([H,AT], {0.6 ∣ 0.8,0.7 ∣ 0.2}, {0.3 ∣ 1})

Table 4. Decision matrix R^3 provided by decision unit Ex^3.

Ex^3	A_1	A_2	A_3	A_4
C_1	([QM,AH], {0.3 ∣ 0.7,0.4 ∣ 0.3}, {0.4 ∣ 0.6,0.6 ∣ 0.3})	([L,M], {0.6 ∣ 0.1,0.7 ∣ 0.8,0.8 ∣ 0.1}, {0.2 ∣ 1})	([AH,T], {0.5 ∣ 0.3,0.7 ∣ 0.7}, {0.1 ∣ 0.5,0.2 ∣ 0.5})	([H,VH], {0.4 ∣ 1}, {0.4 ∣ 0.1,0.5 ∣ 0.5,0.6 ∣ 0.4})
C_2	([AH,H], {0.4 ∣ 0.5,0.5 ∣ 0.5}, {0.5 ∣ 1})	([QM,H], {0.4 ∣ 0.1,0.6 ∣ 0.9}, {0.2 ∣ 0.5,0.4 ∣ 0.5})	([VL,L], {0.3 ∣ 1}, {0.4 ∣ 0.8,0.7 ∣ 0.1})	([VH,T], {0.7 ∣ 0.5,0.8 ∣ 0.5}, {0.2 ∣ 1})
C_3	([L,QM], {0.4 ∣ 0.8}, {0.4 ∣ 0.4,0.6 ∣ 0.6})	([AH,T], {0.7 ∣ 0.9}, {0.1 ∣ 0.2,0.3 ∣ 0.7})	([AM,T], {0.6 ∣ 0.9,0.7 ∣ 0.1}, {0.1 ∣ 0.1,0.3 ∣ 0.8})	([AH,H], {0.3 ∣ 0.2,0.4 ∣ 0.8}, {0.4 ∣ 0.5,0.6 ∣ 0.5})
C_4	([H,T], {0.5 ∣ 0.8,0.7 ∣ 0.2}, {0.3 ∣ 0.9})	([L,AM], {0.5 ∣ 0.4,0.7 ∣ 0.6}, {0.3 ∣ 1})	([QM,AH], {0.3 ∣ 0.3,0.5 ∣ 0.7}, {0.5 ∣ 0.7})	([H,T], {0.5 ∣ 0.1,0.7 ∣ 0.9}, {0.2 ∣ 0.4,0.3 ∣ 0.4})
C_5	([AM,QM], {0.5 ∣ 1}, {0.2 ∣ 0.1,0.3 ∣ 0.6,0.4 ∣ 0.3})	([AH,T], {0.5 ∣ 0.8,0.8 ∣ 0.1}, {0.1 ∣ 0.5,0.2 ∣ 0.5})	([AM,AH], {0.5 ∣ 0.1,0.7 ∣ 0.8}, {0.1 ∣ 0.5,0.2 ∣ 0.3})	([VH,T], {0.4 ∣ 0.8,0.6 ∣ 0.2}, {0.1 ∣ 0.6,0.4 ∣ 0.2})
C_6	([VL,AL], {0.1 ∣ 0.1,0.3 ∣ 0.9}, {0.4 ∣ 0.6,0.6 ∣ 0.4})	([AH,VH], {0.5 ∣ 0.8}, {0.1 ∣ 0.2,0.2 ∣ 0.6})	([L,AM], {0.2 ∣ 0.4,0.5 ∣ 0.6}, {0.5 ∣ 1})	([VH,T], {0.6 ∣ 1},{0.4 ∣ 1})

Subsequently, we apply the **Approach 1** to solve the above specific problem. Detailed steps are illustrated below.

Step 1. The invited decision makers are absolutely trusted and they normally have rational observations on minimum acceptable values and maximal expectation value for each evaluative attribute according to their professional knowledge and abundant field experiences. Therefore, each decision unit is collectively capable of determining their positive ideal destination and negative ideal destination as referential targets. Sometimes the virtual targets actually reflect the standards of governance intervention.

Here suppose all positive ideal destination $A^{\kappa+}$ and negative ideal destination $A^{\kappa-}$ provided by κth decision unit have been established as follows.

$\mathbf{A}^{1+}$ =
{([VH,T],{0.8 | 0.3,0.9 | 0.7},{0.1 | 1}),([AT,T],{0.8 | 1},{0.1 | 0.5,0.2 | 0.5}),([H,T],
{0.7 | 1},{0.1 | 0.8,0.2 | 0.2}),([H,VH],{0.7 | 1},{0.3 | 1}), ([H,T],{0.8 | 1},{0.2 | 1}),
([VH,T],{0.9 | 1},{0.1 | 1});};

$\mathbf{A}^{1-}$ =
{([AM,QM],{0.5 | 0.6,0.6 | 0.4},{0.4 | 1}),([QM,AH],{0.5 | 1},{0.5 | 1}),([VL,L],{0.6 | 0.5,
0.7 | 0.5},{0.3 | 1}),([AL,AM],{0.4 | 1},{0.5 | 0.5,0.6 | 0.5}),([VL,L],{0.6 | 1},{0.4 | 1}),
([AL,M],{0.8 | 1},{0.1 | 0.5, 0.2 | 0.5});};

$\mathbf{A}^{2+}$ =
{([VH,AT],{0.8 | 1},{0.2 | 1}),([VH,T],{0.7 | 0.4,0.8 | 0.6},{0.1 | 0.5,0.2 | 0.5}),([AT,T],
{0.8 | 1},{0.1 | 0.8,0.2 | 0.2}),([AT,T],{0.8 | 0.5,0.9 | 0.5},{0.1 | 1}),([VH,AT],{0.7 | 1},
{0.3 | 1}), ([QH,AT],{ 0.6 | 0.3,0.8 | 0.7},{0.2 | 1});};

$\mathbf{A}^{2-}$ =
{([VL,QL],{0.4 | 1},{0.5 | 0.8,0.6 | 0.2}),([AN,QL],{0.4 | 0.5,
0.5 | 0.5},{0.5 | 1}),([L,M],{0.9 | 1},{0.1 | 1}),([AN,VL],{0.4 | 1},{0.6 | 1}),([L,M],
{0.6 | 0.3, 0.7 | 0.7},{0.3 | 1}),([AN,QL],{0.5 | 1},{0.4 | 0.5, 0.5 | 0.5});};

$\mathbf{A}^{3+}$ =
{([H,T],{0.9 | 1},{0.1 | 1}),([H,VH],{0.8 | 0.8,0.9 | 0.2},{0.1 | 1}),([VH,T],{0.7 | 1},
{0.2 | 0.5,0.3 | 0.5}),([H,T],{0.8 | 0.5, 0.9 | 0.5},{0.1 | 1}), ([VH,T],{0.9 | 1},{0.1 | 1}),
([VH,T],{0.7 | 0.3, 0.8 | 0.7},{0.1 | 0.2, 0.2 | 0.8});};

$\mathbf{A}^{3-}$ =
{([VL,AL],{0.7 | 0.5,0.8 | 0.5},{0.2 | 1}),([VL,L],{0.2 | 1},{0.7 | 0.1,0.8 | 0.9}),([VL,AL],
{0.4 | 0.8, 0.5 | 0.2},{0.5 | 1}),([VL,AL],{0.6 | 1},{0.4 | 1}),([VL,L],{0.6 | 1},{0.4 | 1}),([VL,L],
{0.3 | 0.3, 0.4 | 0.7},{0.5 | 1});}.

Step 2. Based on the decision matrices $R^\kappa = \left(r_{ij}^\kappa\right)_{6\times4}$ and the above $A^{\kappa+}$ and $A^{\kappa-}$, by use of the programming model (M-1), we can objectively calculate the unknown weighting vector: $w^\kappa = (w_1^\kappa, w_2^\kappa, \ldots, w_n^\kappa)(n = 1, 2, \ldots, 6; \kappa = 1, 2, 3)$ for evaluative attributes as

$$w^1 = (0.1359, 0.2317, 0.135, 0.2, 0.1277, 0.1696),$$

$$w^2 = (0.1375, 0.175, 0.1699, 0.2038, 0.1586, 0.1551),$$

$$w^3 = (0.156, 0.1909, 0.1875, 0.1601, 0.1736, 0.1319).$$

Step 3. In accordance with widely adopted configurations of $\alpha = \beta = 0.5$ [53], we can apply the hybrid model in Equation (19) to objectively obtain the unknown weighting vector $\eta^\kappa(\kappa = 1, 2, 3)$ for the three decision units, where $\widetilde{\eta}^1 = 0.3421$, $\widetilde{\eta}^2 = 0.3125$, $\widetilde{\eta}^3 = 0.3455$; $\overline{\eta}^1 = 0.3341$, $\overline{\eta}^2 = 0.3329$, $\overline{\eta}^3 = 0.3331 \Rightarrow \eta^1 = 0.3381$, $\eta^2 = 0.3227$, $\eta^3 = 0.3393$.

Step 4. Next, with the formerly derived weighting vectors of $w^\kappa = (w_1^\kappa, w_2^\kappa, \ldots, w_n^\kappa)$ $(\kappa = 1, 2, 3)$ in **Step I-2**, we utilize the **PDHFUUBLWA** operator introduced in **Approach 1** to aggregate r_{ij}^κ such that we get overall decision result r_j^κ of the κth decision unit on each destination $A_j(j = 1, 2, 3, 4)$. Her for brevity, we only list the overall result of first decision unit on the first destination as following

$$r_1^1 = ([s_{0.4272}, s_{3.3664}],$$
$$\{0.6339|0.0675, 0.6442|0.0675, 0.6478|0.054, 0.6577|0.054, 0.6523 \mid 0.1575,$$
$$0.6621|0.1575, 0.6656|0.126, 0.675 \mid 0.126\}, \{0.2161|0.0504, 0.2692|0.1008,$$
$$0.2283|0.0504, 0.2844|0.1008, 0.2228|0.0336, 0.2775|0.0672, 0.2353 \mid 0.0336,$$
$$0.2931 \mid 0.0672\}).$$

Step 5. Now, with the above obtained weighting vector of $\eta^{\kappa}(\kappa = 1, 2, 3)$ for the three decision units in **Step I-3**, we also apply the **PDHFUUBLWA** operator to aggregate all the individual overall decision results of $r_j^{\kappa}(\kappa = 1, 2, 3)$ into the collective group decision results of r_j $(j = 1, 2, 3, 4)$. Due to the redundancy of $r_j(j = 1, 2, 3, 4)$ output by computer program, specific data have been omitted here for brevity.

Step 6. Lastly, according to the comparative rules defined in Section 2, by applying the score function in Equation (1) to the group overall assessments $r_j(j = 1, 2, 3, 4)$ obtained in Step I-5, we get scores of $E(r_j)$ as

$$E(r_1) = 0.1247, E(r_2) = 0.1637, E(r_3) = 0.3012, E(r_4) = 0.3448.$$

Then, we get the final ranking orders of all destinations under evaluation as $A_1 \prec A_2 \prec A_3 \prec A_4$. Further, based on the ranking result, the NGO or local government can apply effective governance strategies to foster continuous improvements on tourism community resilience in these CBT destinations, such as awarding and stimulating, knowledge sharing and purposeful learning, among others.

7. Conclusions

As rational responses to new normal disturbances in situated environments, integrated development of disaster management and destination management has substantially enriched the CBT governance agenda of DMOs or local governments, among which fostering tourism community resilience through evaluation emerges as an efficient governance strategy but also an urgent and complicate task. For tackling the complicate problem of comprehensive evaluation of tourism community resilience, we have established solutions to several key issues.

(i) Integration of disaster management and destination management (DM2) intrinsically endows the processual characteristics of tourism community resilience, which however have been missing in the literature. To reflect desirable processual characteristics in comprehensive evaluation of tourism community resilience, we thus have constructed an analytical framework that comprises six attributes, i.e., developing proactive preparedness, raising reactive readiness, fostering diverse and innovative economy, nurturing sense of community, consolidating organizational structure of tourism community, and advancing leadership as the core of governance.

(ii) In view of the natural compatibility between uncertain multiple attributes decision making methodology and low/ill-structured problem definition in essence of comprehensive evaluation of tourism community resilience, we have formalized the latter complicate task with a typical process of multiple attributes group decision making.

(iii) In view of the common phenomena that decision makers or decision units exhibit complicate uncertainties when confronting with problems of high complexity, we have put forward a powerful expression tool of probabilistic dual hesitant fuzzy uncertain unbalanced linguistic set (PDHF_UUBLS) to simultaneously capture evaluators' cognitive characteristics of decision hesitancy, bipolar epistemic notions and relative importance among assessments. More importantly, to facilitate rational operationalization of PDHF_UUBLS, we have extended to develop a least common multiply (LCM) under probabilistic hesitant decision settings and theoretically verified the mechanism avoids potential information distortion that occurs in other generally-adopted methods.

(iv) To further support effective decision-making modelling with assessments in the form of PDHF_UUBLS, we have defined some crucial information measures for PDHF_UUBLS, distance measure, entropy measure and cross entropy measure. Also theoretically analyses have verified their desirable properties.

(v) Based on the former building blocks, we further constructed an effective MAGDM approach with special consideration of normal obstacles that weighting vectors for both evaluative attributes and decision units cannot be subjectively determined in advance due to high complexity. We thus have devised corresponding programming models for objectively obtaining those unknown weighting vectors.

Generally speaking, this paper answers to the call of DM2 implementation and provides effective and pertinent solutions to essential tasks of CBT governance agenda. Further investigations will be deployed to establish connections between questionnaire-based methodology and our proposed MAGDM approach, especially with more case studies with regard to CBT implementations in remote areas. Possible efforts could also be spared to construct hierarchical indicator system for tourism community resilience evaluation and develop corresponding decision making frameworks according to specific organization scenarios. Computerization will be another indispensable job to do for facilitating applicability in various CBT destinations.

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Driving Forces for the Spatial Reconstruction of Rural Settlements in Mountainous Areas Based on Structural Equation Models: A Case Study in Western China

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Abstract: Rural settlement development in mountainous areas is the key to eliminating global hunger and poverty. The spatial reconstruction of rural settlements in mountainous areas can promote rural development in mountainous areas. In this study, the Panxi area—a typical mountainous area in China—was chosen as the study area. The driving forces for the spatial reconstruction of rural settlements in mountainous areas were explored from the perspective of peasant households by combining participatory rural appraisal (PRA) with structural equation modeling (SEM). Results showed that: (1) 62.03% of the 266 peasant households included were willing to have spatial reconstruction, indicating that most peasant households in mountainous areas have a very strong intention towards the spatial reconstruction of rural settlements. (2) Infrastructure, medical conditions, living environment, farming culture, and dietary habits significantly influenced the reconstruction intention of peasant households. In contrast, development opportunities, place attachment, language, and living mode each had a slight influence. (3) Geological disasters were the main driving force for the spatial reconstruction of rural settlements in mountainous areas, whilst the driving force of living cohesion was the smallest. This study provides insights for future planning and construction of rural settlements in the Panxi area and spatial reconstruction practices. It has important practical significance for overcoming poverty and realizing rural revitalization in mountainous areas.

Keywords: rural settlement; mountainous areas; spatial reconstruction; SEM; driving forces

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1. Introduction

Rural settlements are important places for rural population life and production and are a space phenomenon. The rural settlement space has been the research key of geographic studies concerning rural settlements [1]. With progress in urbanization and industrialization, many rural settlements face or have entered rapid transformation stages [2]. Rural transformation development is the reconstruction of rural settlement and mainly involves economic, social morphology, and spatial changes [3,4]. In the transformation process, the quality of many rural settlements has been improved, but 'rural hollowing and planned chaos' can coincide. These problems are particularly prominent for rural settlements in mountainous areas with complicated geological environments [5]. In previous studies, Woods (2005) emphasized the reconstruction of socio-economic formations of rural regions resulting from changes to subjects in the transformation process [6]. Li Hongbo et al. (2012) focused more on spatial transformation in rural spaces. They believed that the removal, decline, and disappearance of villages should also be considered reconstruction of rural settlements [7]. Rural space reconstruction is an important manifestation of the reconstruction of rural settlements [8], and the spatial reconstruction of rural settlements is the outlook of reconstructed spatial forms of rural settlement [9]. In the present study, the spatial reconstruction of rural settlements was defined in a narrow sense. That is, to adapt to the development of urban and rural areas, the process of change in the spatial distribution of rural residences is caused by changes to peasant households, which are crucial subjects of rural settlement. Whether spatial pattern changes of rural settlements are reasonable directly determines whether the rural settlement can realize comprehensive, coordinated, and sustainable development. Therefore, promoting the suitable reconstruction of rural settlement spaces in mountainous areas can improve the quality of rural settlement [10].

Exploring the driving forces for the spatial reconstruction of rural settlements is necessary and helps guarantee the effective spatial reconstruction of rural settlements. The spatial reconstruction of rural settlements is accomplished under the collaborative promotion of internal and external driving forces [11]. These include place attachment, historical culture, environment fitness, housing condition and quality, natural disasters, economic levels, infrastructure, government policies, and peasants [12–22]. The government has been the primary driver of rural reconstruction [23–25]. Although such top-down planning is characteristic of high efficiency and rapid construction [26,27], it can ignore the intentions and needs of peasant households. Thus, the outcomes of the reconstruction are not ideal [28]. As the subject of rural settlement, peasant households have the most direct and deepest needs relating to the spatial reconstruction of rural settlements. Reconstruction intention, family structure, policy cognition, risk perception, and the neighborhood of peasant households can influence reconstruction progress [29–32]. During the spatial reconstruction of rural settlements, it is necessary to combine local, practical situations [33] and consider the subjective demands of peasant households [34]. Previous studies on the driving forces for the spatial reconstruction of rural settlements have mainly concentrated on plain regions; however, there are few that have involved mountainous regions and hills [35–38]. The most common measurement models that have been used to study the driving forces for the spatial reconstruction of rural settlements are the Probit and Logit models [29,39,40]. Recently, structural equation modeling (SEM) [41] has also been applied to this area. The Probit and Logit models are used in traditional linear regression analysis. Linear regression analysis defines dependent and independent variables in the model, but it can only provide direct effects between variables and cannot show possible indirect effects. Unlike traditional regression analysis, the structural equation model can handle multiple dependent variables simultaneously and replace multiple regression, path analysis, factor analysis, covariance analysis, and other methods. This model can analyze the effect of individual indicators on the overall outcome and the relationship between individual indicators, which overcomes the limitations of the Probit and Logit models in being unable to explore internal relations among factors intuitively [42]. To date, there have been few studies from the perspective of peasant households on the driving forces for the spatial reconstruction of rural settlements in mountainous areas with complicated geological environments based on the SEM model.

Rural development is the key to achieving the new goal of sustainable development. Nearly 45% of the global population lives in rural areas of developing countries that face issues such as hunger, poverty, and youth unemployment [43]. Poverty eradication is the primary goal of the *Agenda for Sustainable Development in 2030*. Countries worldwide are working towards this goal and trying not to leave anyone behind [44]. Nevertheless, the number of residents in mountainous regions exposed to the risk of food shortage is increasing due to the worsening of mountainous environments, and the poverty problem in mountainous rural areas is particularly serious [45]. As a global agricultural and population power, China still had about six million rural residents across millions of rural settlements in 2017—despite the continuous acceleration of urbanization since the 21st century began. Therefore, rural settlements are still a fundamental residential form for Chinese people [46]. Mountains are extensively distributed in the continents of Eurasia and the Americas. China is also a mountainous country, with mountainous land accounting for nearly 70% of the total land area of China and the location of one-third of the population. The development of mountainous regions is related to poverty eradication for nearly 50% of China's population. Therefore, the development trend of rural settlements in mountainous regions directly influences the national development situation [47].

Against this background, Sichuan Province—a classical mountainous region in China characterized by poverty—was chosen as the research object. The driving forces for the spatial reconstruction of rural settlements in this mountainous area were explored by combining PRA (participatory rural appraisal) and SEM (structural equation modeling). The specific aims of this study were: (1) to combine information on the practical situations and intentions of peasant households in the study area to construct an SEM model about the factors influencing these households' intentions relating to spatial reconstruction of rural settlements; (2) to identify the major driving forces of peasant households' intentions relating to reconstruction; (3) to inform the further smooth reconstruction of rural settlement spaces in mountainous areas.

2. Material and Methods

2.1. Research Area

Sichuan Province is in Southeast China. It has high terrain in the west and low in the east, with extensive coverage by mountainous land [48]; Geological disasters frequently occur in Sichuan Province and threaten the survival and development of rural settlements and peasant households in mountainous regions. Additionally, Sichuan Province is a multi-ethnic province where local peasant households have diversified cultures and ways of thinking, and integrated poverty issues and ethnic-cultural problems [49]. According to relevant statistics [50], a population of 1.71 million in this province was still classified as poverty-stricken, including 5295 poor villages and 68 poor counties, in 2017. These poor regions are mainly in the western mountainous regions of Sichuan Province, which represents a severe challenge to poverty eradication. The complexity of the mountainous environment and the predominance of ethnic minorities exacerbate the difficulties in the spatial reconstruction of rural settlements in mountainous areas. In this study, the main 'battlefield' of poverty eradication in China—the Panxi area of Sichuan Province—was chosen as the study area. The Panxi area is the largest settlement area of Yi people in China. Among China's 14 contiguous destitute areas, the Wumeng Mountains are located in Panxi. The per capita net income of farmers in these areas is 2676 RMByuan, which is only half of the national average. The Panxi area is one of China's most impoverished continuous areas, with a high concentration of ethnic minorities. The urbanization rate in the Panxi area is far lower than the average national level, and there are many problems relating to rural settlements.

2.2. Data Sources

In the present study, data were mainly collected via a questionnaire survey prepared by the research team in January 2018. The survey period started on 25 January, 2018, ended on 3 February, 2018, and lasted for ten days. Due to language barriers, we hired four Yi college students to help us complete the questionnaire survey. The questionnaire focused on the intention of peasant households in mountainous regions relating to the spatial reconstruction of rural settlements, including the influence of housing conditions, living habits, natural disasters, and production conditions. To ensure the representativeness of the selected samples, stratified sampling and then equal probability random sampling were used to determine the research samples [51]. First, Xichang City, Miyi County, Yanyuan County, and Puge County in the Panxi area, where there are many mountain disasters and high spatial conflicts, were chosen as the sample zones based on the team's previous research results [52]. Generally, increased mountain hazards in regions with high spatial development intensity can increase the conflict between people and land. Second, eight towns with different mountain hazards and spatial conflict levels were chosen from the four sampling zones according to the coupled results of mountain hazard risk and spatial conflict [52]. Finally, two villages were chosen randomly from each sample town, from each of which 20 peasant households were chosen randomly according to the household register and random number table [48]. According to the above process, 16 villages and 320 peasant households were chosen. The geological positions of sampled counties and towns are shown in Figure 1.

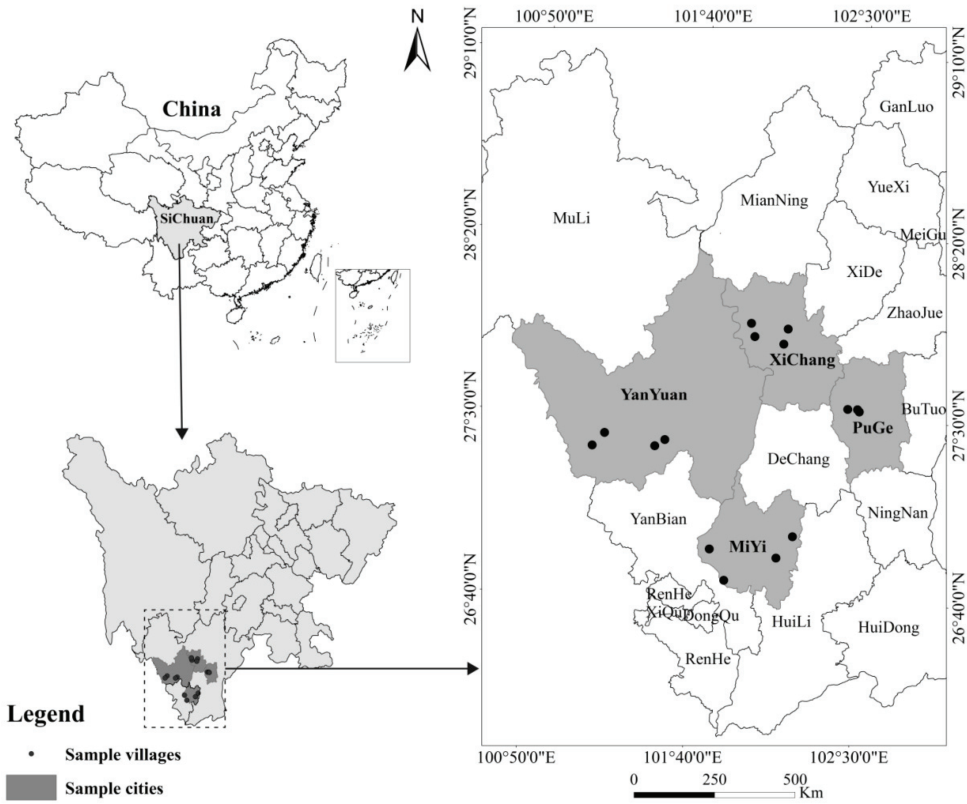

Figure 1. Location of sample cities and villages.

2.3. Variables and Methods

2.3.1. Theoretical Basis

In the 1960s, the American scholar E.S. Lee proposed a systematic theory of population migration, namely 'Push-Pull Theory' [53]. He summarized the factors affecting migration more comprehensively into four factors: a place to move in, a place to move out, intermediate obstacles, and personal factors (Figure 2). The theory is that the factors conducive to improving living conditions become the pulling force that promotes population movement, and the unfavorable living conditions of the emigration area are the pushing force. Both the immigration and emigration areas are affected by two factors: "push" and "pull". When the pushing force in the emigration area is greater than the pulling force, and the pulling force of the immigrating area is greater than the pushing force, population migration will occur [53]. When considering the relocation behavior of rural households, the possible thrust of the relocation area is primarily reflected in the occurrence of natural disasters, poor living conditions, lack of infrastructure, and information blockage in the relocation area [54–56]. Possible pulling factors in migration include many employment opportunities, a high level of education and medical care, sound infrastructure, and diverse information [57,58]. Possible obstacles are farmland culture, pastoral culture, and relocation costs [35,59]. Possible personal factors may be language, eating habits, ways of thinking, cultural qualities, religious beliefs, and living style preferences [14,60–63].

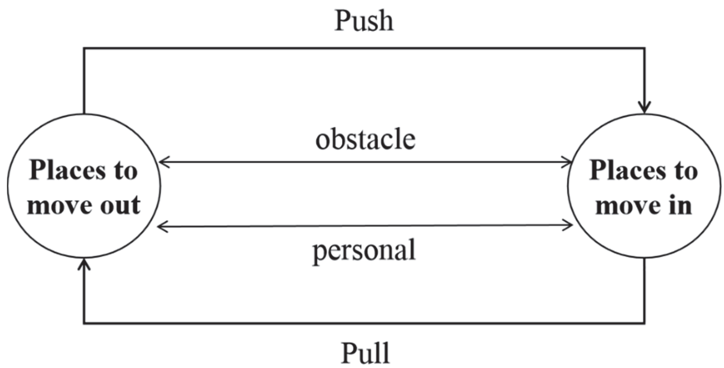

Figure 2. Push-Pull theory framework.

2.3.2. Selection of Variables

The intention of peasant households relating to the spatial reconstruction of rural settlements was set as the dependent variable. If peasant households were willing to reconstruct the rural settlement space, it was valued '0'; otherwise, it was valued '1'. As subjects of rural settlement, peasant households comprehensively consider various factors when choosing a residence, such as the surrounding natural, economic, and social environment [64–66]. These factors also collectively influence the intention of peasant households regarding reconstruction, either by promoting or inhibiting peasant household participation in the reconstruction of rural settlements.

This study explored the factors that were important in influencing the intention of peasant households relating to the spatial reconstruction of rural settlements and determined the major driving forces. Regarding the measurement method and index selection of previous studies [54,56,65,67–69], and with consideration of the practical situation of the study area, five driving forces were selected. These formed the latent variables to measure household intention (Table 1) and were as follows: (1) External attractions (A1–A5): enough employment opportunities, education opportunities, a high-quality living environment, and good public infrastructure. Stronger external attractions were more appealing to peasant households from places with poor settlement conditions. (2) Geological disasters (B1–B4): geological disasters have frequently occurred in the Panxi area. When designing observation variables, questionnaires were set up from the perspectives of the perceived harmfulness of and actual past damage to property caused by geological disasters to understand the peasant households' opinions on the influence of geological disasters on settlement reconstruction. (3) Internal impetus (C1–C5): a multitude of limitations to local development in a region often motivates residents to relocate to better locations. In this study, the internal impetus was assessed from the perspectives of local traffic, water supply, power supply, signals, and the community culture and atmosphere. (4) Production cohesion (D1–D2): historically, residents in the Panxi area have mainly engaged in agricultural cultivation. Peasant households have deep connections to the land. Hence, the production cohesion of peasant households to local settlements was assessed mainly through farming and pasture culture. (5) Life cohesion (F1–F4): the Panxi area contains the highest proportion of the Yi ethnic group in China. With consideration of specific minorities, critical attention was paid to place attachment, diet, language, and living mode when measuring the life cohesion of peasant households to local settlement.

Table 1. Driving forces affecting the reconstruction willingness of peasant households.

Latent Variables	Observation Variables	Definition	Values
External attraction	More development opportunities	A1: If there are more development opportunities in other places, are you willing to move?	Nominal variable: yes = 0; no = 1.
	Good living environment	A2: If there is a good living environment in other places, are you willing to move?	
	Convenient information acquisition	A3: If it is more convenient to obtain information in other places, are you willing to move?	
	Sufficient water and power supply	A4: If other places have sufficient water and power supply, are you willing to move?	
	Good medical conditions	A5: If there are good medical conditions in other places, are you willing to move?	
Geological disasters	Probability of geological disasters	B1: If there is a possibility of geological disasters in your current residence, you will move to another place.	Ordered categorical variable: 1 = strongly agree; 2 = agree; 3 = ordinary; 4 = disagree; 5 = strongly disagree.
	Frequency of geological disasters	B2: If the signs of geological disasters in your current residence become more and more obvious, you will move to another place.	
	Influences of geological disasters on crops	B3: If geological disasters damage the crops, you will move to another place.	
	Economic loss caused by geological disasters	B4: If geological disasters cause economic losses to your family, you will move to another place.	
Internal impetus	Poor traffic conditions	C1: If the road from your village to the town is difficult, are you willing to move?	Nominal variable: yes = 0; no = 1.
	Water shortage	C2: If there is a water shortage in your current residence, are you willing to move?	
	Power shortage	C3: If there is an electricity shortage in your current residence, are you willing to move?	
	Poor communication network	C4: If you are often unable to get through on the phone in your current residence, are you willing to move?	
	Weak community culture atmosphere	C5: If your neighbors in the village are not well-educated, are you willing to move?	
Production cohesion	Farming culture	D1: If there is no land for farming in other places, are you willing to move?	Nominal variable: yes = 0; no = 1.
	Pasture culture	D2: If there is no place to keep poultry in other places, are you willing to move?	
Life cohesion	Place attachment	F1: If there are many relatives and friends in your current residence, are you willing to move?	Nominal variable: yes = 0; no = 1.
	Dietary habit	F2: If other places do not have your current staple food, are you willing to move?	
	Language	F3: If nobody speaks the same language as you in other places, are you willing to move?	
	Living mode	F4: If a new house in other places cannot meet your current living mode, are you willing to move?	

2.3.3. Research Hypothesis

Many previous studies have identified natural disasters as having important influences on the spatial reconstruction of rural settlements. For example, Filippova (2020) and Garakani et al. (2020) found that flood accidents caused significant damage to the houses and farmlands of rural residents, thus forcing post-disaster reconstruction of the villages [70,71]. Vaculisteanu et al. (2019) believed that natural disasters were the most severe threat in rural areas, with landslides being one of the major natural disasters that influenced the spatial reconstruction of rural settlements [21]. Additionally, some scholars have found that quality of life also influenced the spatial reconstruction of rural settlements. For example, Onyemelukwe (1980), Wieruck (2021), and Kasimis (2008) found that many peasant households left villages due to insufficient infrastructure, inadequate education resources, and fewer employment opportunities, relocating to places with better living conditions [72–74]. Cvetkovic (2009) found that some peasant households moved because they wanted a new way of life [60]. Social network relationships also affected the relocation behavior of peasant households. When peasant households first moved to a new place of residence, they were worried about being marginalized by the aboriginals. As they live there longer and longer, peasant households can slowly adapt to the diversity of the community [75,76]. Ethnic minority peasant households usually worry about language barriers and poor dietary habits after moving to the place of migration [77].

Based on existing literature studies and theoretical analyses [41,78–82], an initial SEM model of factors that influenced the intention of peasant households concerning the spatial reconstruction of rural settlements in mountainous areas was constructed (Figure 3). Interaction was assumed between the five latent variables: external attractions, geological disasters, internal impetus, production cohesion, and life cohesion. It was also assumed that more development opportunities, poor traffic conditions, the probability of geological disasters, and place attachment would influence the reconstruction intention of peasant households. The path coefficients of these five variables were fixed at 1.

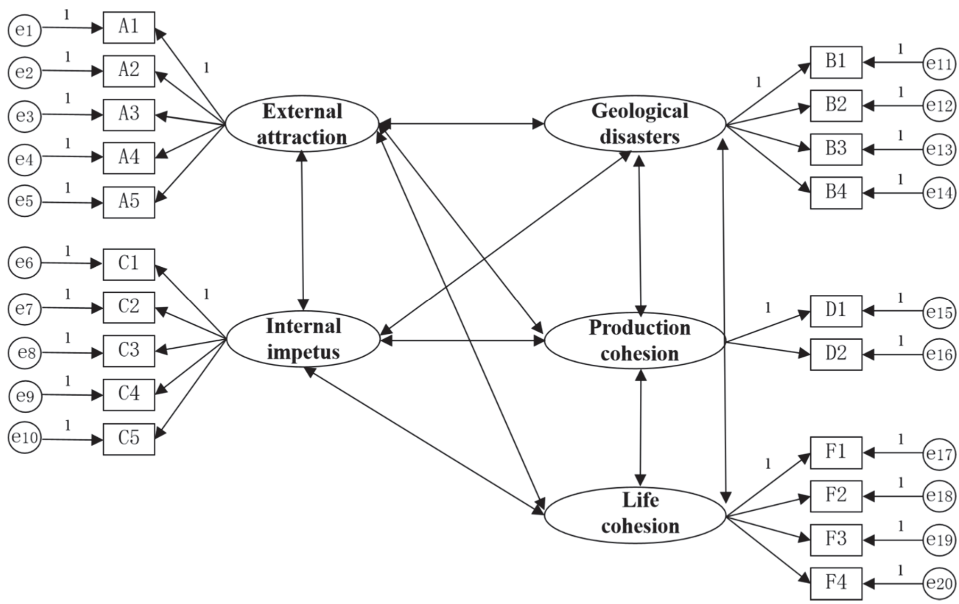

Figure 3. Initial SEM structural equation.

2.3.4. The Models

Structural equation modeling (SEM) is an essential statistical method for the quantitative study of modern behavior in social research. It integrates the factor analysis from traditional multivariable statistical analysis and the statistical approach of regression analysis from linear models. SEM can identify, estimate, and verify several causal models [83]. SEM, or the latent variable model, includes measurement and a structural model. The measurement model is composed of latent variables and observation variables. The relationship between reflective latent variables and manifest variables is usually expressed according to Equation (1), and the relationship between formative latent variables and manifest variables is usually expressed according to Equation (2):

$$X = \Lambda_x \xi + \delta \tag{1}$$

$$Y = \Lambda_y \eta + \varepsilon \tag{2}$$

Here, ε is not related to η, ξ, or δ, while δ is not related to η, ξ, or ε. X is the exogenous observation index, and Y is the endogenous observation index. Λ_x and Λ_y are factor loads of the index variable (x, y). δ and ε are the measurement errors of the observed variables X and Y, respectively, while η and ξ are the exogenous latent variable and endogenous latent variable, respectively. SEM hypothesizes that there is no co-variation or causal relationship between latent variables (common factors) and the measurement errors.

The relationship between latent variables is usually expressed according to Equation (3):

$$\eta = B\eta + \Gamma\xi + \zeta \tag{3}$$

Here, B is a coefficient matrix of $n \times n$ and denotes the relationship between endogenous latent variables. Γ is a coefficient matrix of $n \times m$ and denotes the relationship of exogenous latent variables to the endogenous latent variables.ζ is the residual error of the SEM model and reflects the unexplained part of η in the equation. Analysis of the models in this study was performed using Amos 22.0.

3. Results

3.1. Descriptive Statistical Analysis of Respondents

Among the 266 peasant households, 165 were willing to participate in the spatial reconstruction of rural settlements, accounting for 62.03%. The remaining 101 were unwilling to participate in the spatial reconstruction of rural settlements, accounting for 37.97%. This reflected that most peasant households had a strong inclination towards the spatial reconstruction of rural settlements for villages in the sampled regions (Xichang City, Miyi County, Puge County, and Yanyuan County). Among the 266 peasant households, most had an educational background of either illiteracy or primary school. Most respondents were in good physical condition. Males accounted for 61.28%, and the average age was 44.35 years. Minority groups accounted for 67.67%, with the highest proportion being the Yi ethnicity. Most peasant households (85.34%) were engaged in agricultural activities. Overall, the village populations were mainly middle-aged males from minority groups with low educational backgrounds who were engaged in agricultural production activities (Table 2).

Table 2. Descriptive statistics of the respondents.

Variable	Definition	Mean	Standard Deviation
Gender	Respondents' gender (female = 0, male = 1)	0.39	0.488
Age	Respondents' age (in years)	44.35	14.088
Education	Respondents' education level (illiteracy = 0, primary school = 1, junior middle school = 2, senior high school = 3, junior college = 4, university and above = 5)	1.08	1.248
Health	Respondents' physical health (very good = 1, good = 2, general = 3, not good = 4, very bad = 5)	2.37	1.235
Engaged in agriculture	Are you engaged in agriculture? (yes = 1, no = 0)	0.86	0.351
Ethnicity	Respondents' ethnicity (Han = 1, Yi = 2, Tibetan = 3, other = 4)	1.71	0.518

3.2. Validity and Reliability

First, reliability analysis was carried out on different layers of the questionnaire survey by using Cronbach's alpha. An α value greater than or equal to 0.6 indicates acceptable reliability [83]. It can be seen from Table 3 that Cronbach's α value for the general scale was 0.692, which indicates good reliability. Furthermore, Cronbach's α values for the five scale layers were mainly $\geq$0.6, indicating that the questionnaire had some consistency and stability. The structural validity of the questionnaire was verified by factor analysis. The KMO (Kaiser–Meyer–Olkin) value for the general scale was 0.812, and the KMO values for the five layers of the scale were all higher than 0.5, and the p-value was 0.000 < 0.01.

The Bartlett test of sphericity indicated that factor analysis was applied to the survey data. It can be seen from Table 4 that the principal factors that were screened from the factor analysis conformed to the theoretical structure entirely, and that the cumulative variance contribution rate was relatively high. This demonstrates that the questionnaire has good structural validity.

Table 3. Analysis of questionnaire reliability and validity.

Latent Variables	Observation Variables	Cronbach's Alpha	KMO	Bartlett's Test of Sphericity		
				Approximate Chi-Square	Degree of Freedom	*p*-Value
External attraction	A1, A2, A3, A4, A5	0.936	0.903	2038.165	10	0.000
Geological disasters	B1, B2, B3, B4	0.828	0.795	396.079	6	0.000
Internal impetus	C1, C2, C3, C4, C5, C6	0.632	0.693	164.452	10	0.000
Production cohesion	D1, D2	0.939	0.500	404.238	1	0.000
Life cohesion	F1, F2, F3, F4	0.515	0.659	59.858	6	0.000
Overall		0.692	0.812	3372.221	190	0.000

Table 4. Factor loading matrix after rotation.

		Factor				
		1	2	3	4	5
External attractions	A15	0.657	0.121	−0.095	0.097	0.320
	A2	0.924	0.035	0.157	−0.072	−0.205
	A3	0.926	0.061	0.171	0.007	−0.223
	A4	0.930	0.077	0.165	−0.044	−0.196
	A5	0.930	0.049	0.182	−0.021	−0.204
Geological disasters	B1	0.083	0.836	0.017	−0.012	−0.010
	B2	0.059	0.786	0.085	0.059	0.045
	B3	0.099	0.849	0.026	−0.124	−0.039
	B4	0.001	0.751	0.133	−0.047	−0.201
Internal impetus	C1	−0.017	0.075	0.617	0.113	−0.170
	C2	−0.001	0.190	0.600	0.102	−0.133
	C3	0.277	0.002	0.725	−0.032	0.217
	C4	0.130	0.000	0.591	−0.080	−0.015
	C5	0.150	0.015	0.530	−0.140	0.000
Production cohesion	D1	−0.007	−0.068	−0.015	0.948	0.095
	D2	–0.018	−0.038	0.031	0.938	0.094
Life cohesion	F1	−0.195	−0.051	0.051	−0.158	0.607
	F2	−0.235	−0.140	−0.114	0.148	0.603
	F3	−0.208	0.007	0.232	0.208	0.461
	F4	0.076	−0.010	−0.193	0.369	0.632
Cumulative variance contribution rate		65.026%				

3.3. Fitting and Adaption of Models

The initial model (Figure 2) was verified by survey data and revised according to correction indices. After three paths were added successively, the revised SEM paths were obtained (Figure 4). The two paths e6 ↔ e7 and e1↔e20 passed the significance test and had positive values, indicating that transportation accessibility was positively correlated with the convenience of getting water, selection of living mode, and development opportunities. The new path e10 ↔ e18 passed the significance test and had a negative value. This indicates that a stronger community cultural atmosphere made peasant households easier to contact and accept different dietary cultures. As a result, their dietary habits were more readily changed.

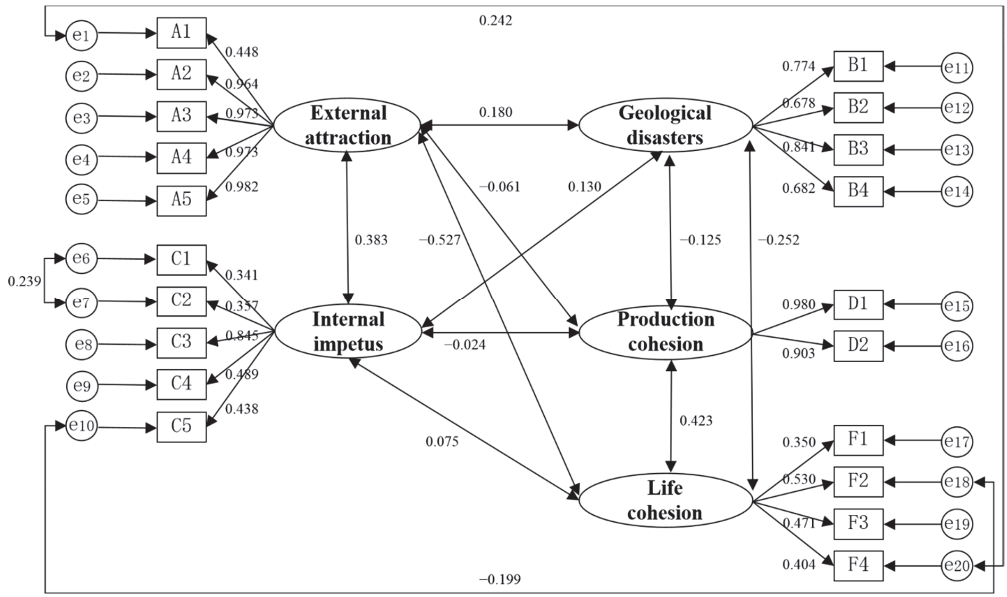

Figure 4. Revised path of the model.

During the fitting evaluation of an SEM model, a higher degree of fitting indicates that the model construction is more reasonable. In this study, the SEM of factors influencing peasant households' reconstruction intentions was verified by confirmatory factor analysis. The results (Table 5) demonstrate that among the absolute adaptation indices for the SEM model, χ^2/df = 1.592 (<3), RMR = 0.024 (<0.05), and RMSEA = 0.047 (<0.05). Furthermore, the SEM fitting indices GFI, NFI, RFI, IFI, TLI, and CFI were all greater than 0.90, and PGFI, PNFI, and PCFI in the simple adaptation index were all higher than 0.50. Therefore, all model indices conformed to the requirements, indicating the good fit of the model.

Table 5. Model adaptation indices.

Evaluation Indices		Fit Standard	Primary Model	Modified Model
Absolute fit indices	$\chi^{2\backslash \mathrm{df}}$	<3, good <5, accept	1.789	1.592
	GFI	>0.9	0.902	0.916
	RMR	<0.05	0.024	0.024
	RMSEA	<0.05, good <0.08, accept	0.055	0.047
Incremental fit indices	NFI	>0.9	0.918	0.928
	RFI	>0.9	0.902	0.913
	IFI	>0.9	0.962	0.972
	TLI	>0.9	0.954	0.966
	CFI	>0.9	0.962	0.972
Parsimonious fit indices	PGFI	>0.5	0.688	0.685
	PNFI	>0.5	0.773	0.767
	PCFI	>0.5	0.810	0.803

Note: GFI is goodness-of-fit index; RMR is root mean square residual; RMSEA is standardized root mean square residual; NFI is normed fit index; RFI is relative fit index; IFI is incremental fit index; TLI is Tacker-Lewis index; CFI is comparative fit index; PGFI is parsimony goodness-of-fit index; PNFI is parsimony-adjusted NFI; PCFI is parsimony-adjusted CFI.

3.4. Recognition of Driving Forces

The non-standardized regression coefficient was calculated by the maximum likelihood method (Table 6). The standard deviations and critical values of the probability of geological disasters, poor traffic conditions, farming culture, and place attachment are blank because these five factors were set as fixed parameters in the initial modeling.

Table 6. The regression coefficient of path.

Items			Non-Standardized Estimate	Standard Error	Critical Ratio	Standardized Estimate
A14	←	External attraction	1			0.448 ***
A2	←	External attraction	2.034	0.25	8.144	0.964 ***
A3	←	External attraction	2.11	0.258	8.166	0.973 ***
A4	←	External attraction	2.11	0.258	8.165	0.973 ***
A5	←	External attraction	2.12	0.259	8.184	0.982 ***
B1	←	Geological disasters	1			0.774 ***
B2	←	Geological disasters	0.877	0.083	10.532	0.678 ***
B3	←	Geological disasters	1.005	0.08	12.546	0.841 ***
B4	←	Geological disasters	0.984	0.093	10.596	0.682 ***
C1	←	Internal impetus	1			0.341 ***
C2	←	Internal impetus	1.008	0.234	4.306	0.357 ***
C3	←	Internal impetus	1.972	0.434	4.546	0.845 ***
C4	←	Internal impetus	1.273	0.295	4.312	0.489 ***
C5	←	Internal impetus	0.949	0.229	4.14	0.438 ***
D1	←	Production cohesion	1			0.980 ***
D2	←	Production cohesion	0.934	0.093	10.097	0.903 ***
F1	←	Life cohesion	1			0.350 ***
F2	←	Life cohesion	1.494	0.364	4.11	0.530 ***
F3	←	Life cohesion	1.208	0.306	3.943	0.471 ***
F4	←	Life cohesion	1.081	0.291	3.719	0.404 ***

*** Significant at $p < 0.001$

(1) Among the external attractions, the standardized regression coefficients of good medical conditions, sufficient water and power supply, convenient information acquisition, and a suitable living environment were all higher than 0.960. This reflects that these factors had significantly positive effects on the reconstruction intention of peasant households. To seek better living conditions, peasant households were more willing to accept the spatial reconstruction of rural settlements. Among external attractions, the path coefficient of more development opportunities was fixed at 1, and the standardized regression coefficient was 0.448, indicating that development opportunities (e.g., employment and education) had positive impacts on the reconstruction intention of peasant households. However, development opportunities were not highly related compared with other external attraction factors.

(2) Among geological disasters, the path coefficient of the probability of geological disasters was fixed at 1, and the standardized regression coefficient was 0.774. The standardized regression coefficients of the frequency of geological disasters, the influence of geological disasters on crops, and economic loss caused by geological disasters were 0.678, 0.841, and 0.682, respectively. Of these, B3 (the influence of geological disasters on crops) was the top factor that influenced the reconstruction intention of peasant households, while the other three factors also had relatively significant positive impacts on the reconstruction intention of peasant households. Most peasant households in surveyed villages had experienced geological disasters. They were mainly engaged in agricultural production, with crops forming their primary income source and survival foundation. They believed that geological disasters could affect crop outputs and even their houses, greatly influencing their current residence.

(3) For internal impetus, the standardized regression coefficients of a weak community cultural atmosphere, poor communication network, power shortages, and water shortages were 0.438, 0.489, 0.845, and 0.357, respectively. The path coefficient of poor traffic conditions was fixed at 1, and the standardized regression coefficient was 0.341. All these factors significantly influenced the reconstruction intention of peasant households. Specifically,

power shortage was the primary influencing factor, followed by a poor communication network. This reflects that the imperfect communication networks and electronic devices in current residences brought great inconvenience to the daily life of peasant households. Peasant households had a stronger reconstruction intention if they had lower satisfaction with their current residential environment. Furthermore, the community cultural atmosphere had a slightly positive influence on the spatial reconstruction of rural settlements. Water shortages and poor traffic conditions had positive effects on the reconstruction intention of peasant households; however, these effects were minimal.

(4) Among the production cohesion factors, the path coefficient of farming culture was fixed at 1, and the standardized regression coefficient was 0.980. The standardized regression coefficient of pasture culture was 0.903. This indicates that farming culture and pasture culture were significantly positively correlated with the reconstruction intention of peasant households. Peasants prefer places where they can plant crops and feed poultry, as they depend on the planting and breeding industries. When there was a more robust farming culture and pasture culture, peasant households were worried that there was not enough land for agricultural and poultry industries and had a stronger reconstruction intention.

(5) In the life cohesion factors, the path coefficient of place attachment was fixed at 1, and the standardized regression coefficient (0.350) was lower than for the other three factors. This indicates that place attachment was not highly correlated with the reconstruction intention of peasant households. The standardized regression coefficients of dietary habit, language, and living mode were 0.530, 0.471, and 0.404, respectively. Of these, language, living mode, and place attachment positively affected the reconstruction intention of peasant households; however, these effects were small. Dietary habits was the top influencing factor of the reconstruction intention of peasant households. This was because most peasant households are minorities with unique dietary habits and are highly unwilling to change their current staple food. Dietary habits had a considerable positive influence on the reconstruction intention of peasant households.

4. Discussion

This study combined participatory rural appraisals with a structural equation model. It analyzed the influence of people's willingness on behavior choices from the perspective of peasant households to explore the driving force of behavior results. The SEM method is an important analysis tool in quantitative research. For conceptual indicators that are difficult to directly and accurately measure, such as psychology and society, the SEM model provides a method to account for measurement errors—using multiple indicators to reflect potential variables. This study method is more accurate and reasonable than the traditional regression methods and has many applications, such as psychology, management, and other related research. Scholars can design questionnaires according to their own research goals to study people's behavioral motivations.

This study obtained conclusions consistent with those of Garcia (2009), Pritchard (2012), and Wierucka et al. (2021). That is, that external attractions are important drivers of the spatial reconstruction of rural settlements. Specifically, places with better infrastructure, including good medical conditions and sufficient water and power supply, are more attractive to peasant households and result in a stronger reconstruction intention of peasant households. Additionally, the living environment is an important factor that people consider in choosing a residence. Indeed, people impose higher and higher requirements on their quality of life with improved economic levels in western developed countries. A suitable living environment is a premise and basis for a high quality of life [74,84,85]. Convenient information acquisition and more development opportunities help guarantee a high quality of life [86,87]. A different research conclusion of the present study compared to previous studies was that development opportunities (e.g., employment and education) had significantly positive effects on the reconstruction intention of peasant households, but these effects were not very significant. This may be related to implementing the rural revitalization strategic policy in the Panxi area in recent years. Increasing anti-poverty projects have been introduced in the Panxi area, which has provided more employment and education opportunities for local people. This may explain why local peasant households did not have a stronger intention to relocate to places with more development opportunities.

Many countries have researched the driving forces of place attachment in the spatial reconstruction of rural settlements. However, there have been few studies relating to place attachment in China. Place attachment is composed of local dependence (functional attachment) and local identity (emotional attachment) [88]. Barcus (2010) and Malik and Yoshida (2020) found that place attachment could promote the spatial reconstruction of rural settlements. One of the important factors that affected peasant households' intention to move to a better place was local attachment [89,90]. However, the present study found that although place attachment was one factor that peasant households considered in migration, it was not decisive. All respondents lived in mountainous areas in the Panxi area, where power shortages, geological diseases, and poor living conditions were common. As these places do not provide the ideal residential mode, peasant households had a low emotional and functional attachment to their current residential areas. It was interesting that life cohesion influenced peasant households' intentions relating to the spatial reconstruction of rural settlements the least, which was different from the research results of Deumert (2005) and Sami (2013) [91,92]. This may have been because, with the development of the social economy, local peasant households had increasing contact with people in other places and gradually began to become familiar with and accept the cultures, diets, and living modes of other ethnicities. Therefore, life cohesion was not the primary factor that peasant households considered during the spatial reconstruction of rural settlements.

The unique geological environment in mountainous regions intensifies unfairness and differences in the development among rural settlements. Rural settlements in mountainous regions develop more slowly and with more difficulty than those on plains. Suppose the spatial reconstruction of rural settlements in mountainous areas is unreasonable. In that case, it will inevitably result in or intensify the worsening of the ecological environment and geological disasters, thus posing an increased threat to the life and property of residents. Previous studies have found that the intention of peasant households plays an essential role in the spatial reconstruction of rural settlements [12,40,93]. Government-guided rural planning often fails if it does not respect the intention of peasant households and forces them to move [28,94,95]. Hence, exploring the driving forces for the spatial reconstruction of rural settlements by considering the intentions of peasant households can lead to the implementation of rural planning and construction that are closer to the ideal living mode of peasant households. This would encourage peasant households to take the initiative in reconstruction, thus decreasing conflicts between them and the government.

This study has made the following novel contributions: (1) The Panxi area in Sichuan Province, a typical mountainous region in China, was chosen as the study area to explore the driving forces of the spatial reconstruction of rural settlements in mountainous areas. (2) From the perspective of peasant households, this study explored the five driving forces of external attraction, internal impetus, geological disasters, production culture, and life culture in the spatial reconstruction of rural settlements in mountainous areas. (3) Place attachment was used as an influencing factor in peasant households' reconstruction intention. It was added to study the driving forces of the spatial reconstruction of rural settlements in mountainous areas. This study provides an important guide for the implementation of rural planning and construction in the Panxi area in the future. It can also provide references for the study of driving forces for spatial reconstruction of mountainous rural settlements in other cities or countries.

This study had certain limitations that can be addressed in future research. The spatial reconstruction of rural settlements is complicated and influenced by many factors. This study did not consider peasant households' unique features, family features, and policy perceptions. A supplementary questionnaire survey will investigate these factors. Additionally, future studies will explore the reconstruction mode of rural settlement spaces based on the identified driving forces.

5. Conclusions and Implications

In this study, the driving forces for the spatial reconstruction of rural settlements in mountainous areas were explored by using the questionnaire survey data of rural families in the Panxi area of Sichuan Province, China, from 2017, and establishing an SEM. The following major conclusions were drawn:

(1) Among the 16 sampled villages in the Panxi area, most peasant households had a very strong intention towards the spatial reconstruction of rural settlements.

(2) Important factors that influenced the reconstruction intention of peasant households were infrastructure constructions (e.g., electronic facilities and medical conditions), the living environment, the convenience of information accessibility, the farming culture, the pasture culture, dietary habits, and geological disasters.

(3) Place attachment, living mode, language, traffic, water resources, and development opportunities slightly influenced the reconstruction intention of peasant households.

(4) Geological disasters were the main driving force for the spatial reconstruction of rural settlements in mountainous areas, while life cohesion had the least influence.

The spatial reconstruction of rural settlements is an inevitable change in conformance with social and economic development. Although the spatial reconstruction of rural settlements in mountainous areas faces various challenges, the extensive support of peasant households in mountainous areas proves it is the right time for rural space reconstruction. The occurrence of geological disasters poses an overwhelming threat to the safety of rural households in mountainous areas. The Chinese government has introduced a relocation policy for poverty-stricken peasant households living in deep mountains, such as those with many geological disasters, inconvenient transportation, limited information, and poor living conditions. By improving the infrastructure of the resettlement area, supporting education and medical facilities, and guiding the employment of peasant households, the government can attract rural households in mountainous areas to relocate to resettlement areas with better living conditions, such as central villages, central towns, or industrial parks. This model can promote rural revitalization; the furthering of plans for broader, coordinated urban-rural development; and land-use management policies. After peasant households in mountainous areas moved with government assistance, their original homesteads were demolished. The government adjusted the land suitable for farming to reclaim and return to farming through the transformation of villages and towns and the merging of villages and townships, dramatically improving land-use efficiency. The most important thing is that during the spatial reconstruction of rural settlements, governments should consider a combination of the specific local rural conditions, peasant households' reconstruction intentions, and important influencing factors for these households as the basis for rural planning and construction. Such spatial reconstruction of rural settlements via government guidance combined with peasant household participation would facilitate an efficient reconstruction process by showing respect for their intentions.

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Article

The Smart Village Concept and Transport Exclusion of Rural Areas—A Case Study of a Village in Northern Poland

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Abstract: The aim of the article is to present transport accessibility in rural areas in Poland, with a particular emphasis on the problem of transport exclusion. The following research methods were used in the study: literature review, statistical data analysis and GIS analysis. The article presents a transportation picture of rural areas and identifies the main problem issues related to the insufficient accessibility of public transport. The conducted analyses show a significant alienation of the study area which results from underdeveloped public transport and road infrastructure, including pedestrian and bicycle routes. Measures taken by local authorities in this regard show awareness of the problems of the local community, but those authorities do not take sufficient action. The transport exclusion of inhabitants of the analyzed area can be reduced by developing pedestrian and bicycle infrastructure connecting villages with the existing railway network, characterized by a high frequency of trains.

Keywords: smart village; GIS analysis; public transport

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1. Introduction

Development differences between urban and rural areas are systemic and deeply rooted in the history of regions [1]. An increase in interest in rural development can be observed in recent years, both in the scientific literature and in the public debate [2]. There are noticeable differences in the approach to defining smart villages between Europe and Asia, Africa, and the Americas [3]. They concern smart areas where new solutions—policies and strategies—are implemented. In Europe, the main focus of researchers has been on social innovation, to the exclusion of environmental issues. In Poland, a revolution in the approach to rural development occurred after joining the European Union, when Poland was confronted with the realities of market and international competition. The problems of rural areas were exacerbated by a collapse of regional transport [4] and, among others, liquidation of the socialized sector [5], which led to an increase in unemployment, digital exclusion, limitation of access to public services or deterioration in the quality of life [6].

Regional transport includes individual and collective transport. The latter is most often realized as part of public services (public transport). Infrastructure, transport distribution and transport in the public and private formula are among the main factors of regional growth [7]. In the case of Poland, the issue of public transport is associated with the political changes of the 1990s related to the so-called "post-communist transformation", which significantly contributed to changing the mechanisms of supporting residents in terms of providing them with access to public transport, especially in smaller towns [8]. Similarly, its role was becoming less important every year along with a fall in prices of passenger cars. Owning them still marked a high social status in many countries. Persons forced to travel exclusively by public transport, especially regional transport, have to face many problems—poor quality of transport, mismatch between the offer and the actual needs, high fares, or frequent changes in timetables. Most of them result from an inadequately implemented transport policy by local and regional authorities [9–11].

Villages are characterized by significant problems related to the dispersion of access to transport services and to the resulting transport poverty and poor quality of public transport. As a result, this leads to a decline in passenger numbers in rural areas [12,13]. Inhabitants of villages are exposed to a much higher risk of social exclusion and the related deterioration in the quality of life [14] especially as regards the group of young and elderly people [13,15]. Inaccessibility of rural areas in terms of transport translates into lower education, difficulties in access to public services, as well as limited social bonds. Transport-excluded villages may become so-called enclaves of poverty and social collapse [13]. In such places, residents experience stress related to social exclusion, including addiction, aggression, or depression [16]. This is also linked to the increased number of suicides among male farm workers—this is already a serious social problem [17]. Counteracting social exclusion in rural areas should be largely based on measures related to counteracting transport poverty, which can bring many benefits to local communities [18].

The research addressed completes the knowledge of the implementation of the smart village concept in Central and Eastern European countries (CEE). During the political transition, rural areas found themselves in a difficult situation—high unemployment, risk of poverty, social problems, or migration to larger cities. Research shows that after almost 30 years, rural areas of CEE countries are still facing problems, including mobility. The collapse of regional transport and the neglect of infrastructure is a serious problem today. The analysis presented in this article, supported by a literature review and a case study, provides a framework for local authorities to take action to improve transport accessibility. However, it should be noted that the most important action remains at the national level, which is able to stimulate local action. The article synthesizes the benefits of the smart village concept through examples of how the concept has been implemented in European countries, particularly in CEE countries. The benefits were supported by a case study that can provide a framework for change in strategic planning for local authorities.

The research aimed to analyze transport accessibility in Poland, with particular emphasis on rural areas, and to present a case study of a selected place characterized by significant social and transportation alienation. Opportunities to counteract this phenomenon were presented, thanks to original solutions based on the concept of smart villages. The study involved a critical analysis of statistical materials concerning the subject of transport availability in Poland. In the context of the conducted analysis, data for rural areas were presented, with particular emphasis on the region in northern Poland. The work is completed with the case study with original solutions and recommendations of an applicatory nature. The paper ends with conclusions listing detailed determinants of the emergence of transport exclusion in rural areas and key opportunities to counteract this phenomenon.

2. Rural Development Issues and the Smart Village Concept

Rural development is a complex process. It concerns the improvement of the quality of life and economic well-being of people living in rural areas. This development is generally realized through the implementation of socio-economic programs and infrastructure projects.

Although the concept of rural development, also sustainable rural development, has existed in the current discourse for decades, it is noticeable that it has been addressed with particular interest in recent years [4]. The main reason for this is the growing awareness of both the problems faced by rural areas in view of the various challenges, including especially those of a climatic nature. Rural areas also play an important role in global development. It is also important to even out development disparities between urban and rural areas.

The literature on rural development issues is abundant with research that focuses primarily on a few key research areas. These include studies on disparities in access to basic needs (e.g., water, food), services (e.g., electricity, education, health care) or the labor market. If rural residents do not have access to basic needs or services, this has serious consequences, such as higher rates of disease or mortality among residents compared to urban areas. For rural areas, activities aimed at building new infrastructure, both linear and point-to-point, are also important. New road or rail infrastructure can be critical to rural socio-economic development and poverty reduction. It is particularly important for those facing social exclusion, a classic example of which is transport exclusion, which strongly distinguishes rural from urban areas. For rural communities, the lack of access to various services or a better labor market is influencing increased migration to cities, thus contributing to the depopulation of rural areas [19]).

For several years now, rural areas have also become the main beneficiaries of various policy measures at various levels aimed at their sustainable development, as exemplified by the European Union. Sustainable development policies are based on taking integrated action in three key areas of human functioning: economic, social, and environmental areas. Policy makers have recognized that bottom-up actions are beneficial and necessary as they support the development process, but that a top-down (systemic) approach is needed, in terms of guiding development, financial support frameworks, monitoring and evaluation.

Currently, the development of rural areas is shaped by the European Union policy and by national and regional activities. An increase in interest in the countryside results partly from trying to counteract the depopulation of these areas, and partly from seeing a threat of the socio-economic collapse of rural areas. Many villages in Poland are depopulated, and the remaining residents—usually the oldest ones—live without access to basic services, including grocery stores and health care [20].

“A long-term Vision for the EU’s Rural Areas—Towards stronger, connected, resilient and prosperous rural areas by 2040” [21] is a strategic document in the field of rural development, according to which the main factors in rural growth are actions to improve the quality of the environment and digitalization. This document sets out the directions of rural development in four categories: community, resilience, communication, and perspectives. Another important document is “A Farm to Fork Strategy”, which focuses on the aspect of healthy food and resilience to climate change. Although it emphasizes the agricultural dimension of rural areas, this strategy concerns the European community in general—it indicates equal access to cheap, local, and healthy food. This is recognized as a fundamental right of every human being. Both documents are part of the strategy of the “European Green Deal” [22], whose main objective was to transform Europe into the first climate-neutral continent by the end of 2030.

Rural policy primarily focuses on climate resilience and an improvement in the population’s quality of life. However, these assumptions cannot be fulfilled without a systemic approach, i.e., an action plan. Today’s rural areas need development strategies just as much as cities do [23]. However, due to their different nature, it should be an action plan adapted to the nature of a village, i.e., its diversity. Rural areas in CEE countries are characterized by slightly different problems than in Western Europe, which significantly affects the effectiveness of European strategies implemented in CEE countries. Rural areas of CEE countries are much poorer and the problem of poverty there is multidimensional, as poverty is a result of the transformation process [24]. The proposed idea of ‘smart villages’ is such a concept. Like its urban counterpart, it is characterized by a systemic approach, treating the rural area as a coherent whole. Smart villages are defined as rural communities that use an innovative approach and technologies in order to increase their resilience, quality of life and development opportunities in the field of economy, social development, and participation, health, and communication [25–27]. Based on an in-depth analysis of literature on rural development and the quoted definitions, the concept of smart villages is presented in the form of a development model focused on activities concerning five basic categories: Resilience, Mobility, Community, Perspectives and Digitalization (Table 1) [25–27].

Table 1. Model of smart villages (own study, based on [25–27]).

Category	Features
Resilience	implementation of pro-ecological measures and solutions, production, and high availability of local food, strengthening hard and soft skills among the inhabitants of rural areas of working and pre-working age
Mobility	ensuring collective and individual public transport in rural areas, including micromobility, e.g., rural bicycle systems or the mobility-as-a-service concept (MaaS), modernization of existing road and rail infrastructure and construction of new connections
Community	actions to build a cohesive and active rural community, social participation
Perspectives	actions to build a cohesive and active rural community, social participation
Digitalization	ensuring access to the Internet, including for elderly people and people threatened by digital poverty or social exclusion; digitalization of public services

The model distinguishes five categories, key from the point of view of rural development: resilience, mobility, community, perspectives, and digitalization (Table 1). There are some similarities to the traditional approach to the smart city concept in six areas; however, being newer [26,27], the smart villages concept significantly updates the original assumptions of six areas, also on the basis of the pandemic experience associated with COVID-19 which verified the traditional approach to smart development.

Currently, the interest in an innovative and ecological approach to development issues is growing, but as regards rural areas, fragmentation of activities can be noticed [27]. These are usually initiatives by the agricultural sector to build a new business model that would link agriculture with trade or services. Such initiatives include the "The Farma Brezany" company from Slovakia, producing pellets out of horse manure or the herbal garden "MAJNIKA" from Slovenia [28–30]. Activities related to producing food, breeding farm stock, strengthening local communities and developing tourism dominate [31]. The smallest share of innovation concerns transport in rural areas. There are only few such initiatives: the Austrian "FUMObil", i.e., electric buses reaching every village in the region, a system of rural cargo bikes in Burgsteinfurt in Germany or a system of shared electric cars from France [32]. The German experience highlights the necessity of co-creation and implementation of IoT solutions in rural areas. The 'Digitales Dorf Bayern' project was primarily aimed at improving the quality of life of local residents through access to information and services on a mobile app [33]. In the Czech Republic, in contrast, the implementation of smart villages was based on the cooperation of three thematic areas—environment and energy, agriculture and education. The aim of the policies implemented was, for example, to ensure efficient energy use in buildings, improve energy and transport infrastructure, educate about energy, or support the development of alternative energy [34].

The issue of transport exclusion is complex, which results in low interest from both private entrepreneurs and local authorities. There is no doubt that efficient, accessible, and safe transport determines the well-being of the rural population [35]. Without providing public transport services, it is impossible to build a resilient and equal society. Globally, the smart village concept is rarely associated with public transport, which may be due to different considerations. In Europe, however, public transport is an important component of smart villages [36]. Poorly functioning public transport contributes to social exclusion, exacerbation of poverty and unemployment, and a reduction of development opportunities for young people from rural areas. It should be noted that the issue of mobility, especially infrastructure, is a critical point in the implementation of the smart village concept. Above all, there are very different levels of development between countries and regions. At the same time, in many places' infrastructure investments should precede the implementation of innovations [23].

It should be noted that the issue of mobility in rural areas in general has been marginalized in order to promote mobility in urban areas. There was a greater focus on improving mobility in cities or suburban areas closely related to the city than in villages, especially peripheral ones. The fundamental difference primarily results from the distance and the condition of connections to broadly understood service centers, such as shops or workplaces. For example, in rural areas, insufficient distribution of transport connections is a common problem. Rural areas are also characterized by an increased number of bottlenecks, i.e., an underdeveloped and inefficient (transport) system which is a serious obstacle to mobility. In order to counteract this, specific strategies are needed to increase the sustainable mobility of rural communities [29]. It is worth noting that the smart village model means not only actions taken top-down by rural decision-makers, such as a local government, but also active participation of the rural community in these activities [37].

The issue of the development of mobility in rural areas should be approached using a more diverse formula than in the case of shaping mobility for urban areas. In particular, this is due to differences in the distance between the city's borders and access to the necessary needs, and in the case of rural areas to relatively more distant locations of desired services. The population density, which affects the economic efficiency of transport, is also important. In the case of rural areas, the level of subsidies for transport services must often be higher than in the case of cities. The smart village model pays special attention to mobility in the context of its role of sharing [35]. Shared mobility can be one of the basic solutions to combat social and transport exclusion in rural areas. Simultaneously, it can be a cheaper alternative to traditional public transport. It can be defined as a set of practices aimed at changing private ownership to temporary ownership or sharing different means of transport, most often individual—bicycles, scooters or passenger cars [35]. Examples of shared mobility services include, but are not limited to, rural/urban bicycle systems, social networks for the exchange and sharing of individual means of transport or supporting other members of rural communities in increasing their mobility [35,38]. Car ownership depends largely on place of residence and income. The most common car owner is a rural resident with a relatively high income [39]

First of all, the model of sustainable mobility in rural areas should point to three basic components, which include (1) making available and sharing one's own resources, among others sharing private means of transport, such as passenger cars or bicycles, (2) making available and sharing trips with a shared means of transport, carpooling, voluntary activity in the field of increasing mobility or safe hitchhiking, and (3) efficient transport services, which include, among others, increasing the flexibility and efficiency of the trip by designing and setting out flexible and resource-efficient door-to-door routes [35,40,41]. The issues of mobility in rural areas are connected with the issue of limited intra-regional communication, the issue of forced motorization and high degree of residents' self-organization in the field of mobility. This problem is so vital in socio-economic and environmental terms that more attention should be paid to it. Statistics show that in rural areas men dominate in the proportion of passenger vehicle drivers. Women, the elderly or people with disabilities are exposed to the effects of social exclusion, due to their low mobility determined, among others, by their lower incomes preventing them from obtaining a driving license and buying a private means of transport or due to cultural conditions [42]. Mobility patterns and their distribution by gender are also key in this aspect. Statistically, it is women who are less mobile than men when it comes to the use of cars for daily mobility. This is due, among other things, to historical and cultural issues or also financial issues related to access to a car—driving-license course, purchase of a car [42]. Shared mobility, as shown in the presented model, is one of the solutions to this problem. It can support the sustainable inclusion of the rural community in social life or the improvement in the residents' private situation by creating better earning opportunities.

3. Materials and Methods

The main research methods applied in the study include the analysis of existing and secondary data [43]. The data used to conduct the meta-analysis are of both a quantitative and qualitative nature. The scope of research activities is based on modelling, processing, and critical analysis of national and international literature on the subject. The distribution of the research process is presented in Figure 1.

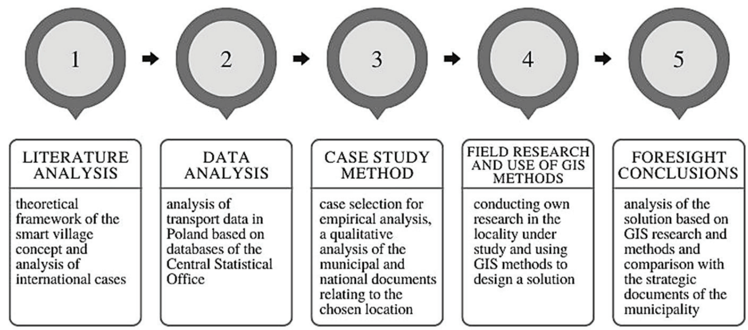

Figure 1. Research methodology in the subsequent phases.

Scientific publications and specialized reports as well as public statistical data have been taken into account. The literature analysis was based on databases: Google Scholar, EBSCO, and Wiley. The literature review focused on Central and Eastern Europe and Poland. Items were selected on the following keywords—smart village, intelligent village, transport exclusion, social exclusion, transport poverty. The literature was then reviewed for relevance to the subject of the paper and a working report was produced. It included information on defining keywords in the literature. First of all, these statistical data were published by Statistics Poland (GUS) in the form of an open database called the Local Data Bank (LDB). Statistics Poland is part of government administration in Poland whose primary task is to collect, process and share statistical data that cover the majority of public and private life in the country [44]. Data are aggregated by fields which include—population, national censuses, territorial division, transport, and communication. The indicated statistical data were expanded with statistical resources from the Regional Statistics database, which primarily focuses on an in-depth data set for particular regions [44]. Statistics for the northern region of the country were used for the purposes of this study.

The study also used an analysis of the spatial data using GIS tools (Geographic Information Systems) to illustrate transport accessibility in the form of cartographic studies. In this modelling, the Topographic Objects Database [45] was used. According to the Regulation of the Minister of Development, Labor, and Technology of 27 July 2021, it is a database that collects information covering the spatial location of topographic objects in the scale of 1:10 000, contained in the applicable state spatial reference system [46]. First of all, they are of a vector character, and for the needs of this study, in order to visualize and analyze, a set of categories of objects in the form of a transportation network and territorial division units was used. The analysis of the GIS spatial distribution was supplemented with the conducted field study in the form of, among others, measurement of the time needed to cover a specific distance or spatial inventory.

In addition, the article uses the case study method. Several factors influenced the choice of the specific location [47]:

- Own observations,
- Proximity to the Tri-city agglomeration, which is the largest development center in northern Poland,
- Good accessibility of regional railways, but lack of metropolitan railways,
- Lack of bus connections.

The case study Głuszyno is located between two regional towns: Słupsk and Lębork. The village is also located in the vicinity of a large urban center, i.e., the Tri-city agglomeration. Głuszyno has direct railway connections with the agglomeration (regional railway) but is not served by the metropolitan railway. Despite a good rail connection, residents face a lack of accessibility to the railway station. The access road to the station is missing, as is a pedestrian walkway and cycle path. Hence, the case of the village of Głuszyno stands out compared to other villages, but this does not mean that it is only here that residents have difficulties in accessing public transport. The village of Głuszyno can be considered a clear case, which nevertheless draws attention to a problem common in the countries of Central and Eastern Europe, which, after the transformation process, face the problem of rural alienation. Based on the field research and the qualitative analysis of the Potęgowo Municipality Development Strategy, a model solution for improving transport accessibility to the railway station was created.

4. Results

4.1. Transport Exclusion in Poland

The issue of transport exclusion in CEE countries dates back to the 1990s, i.e., the beginnings of systemic transformation towards a free market economy [48,49]. This period was characterized by a high level of inflation, a high unemployment rate and numerous changes in legal regulations. The collapse of the communist state caused an economic crisis of unprecedented strength, which led to significant impoverishment of the population and numerous problems of state-owned companies. As a result of the changes, many people found themselves in a difficult financial situation—on the verge of poverty. Simultaneously, the entire transport system changed, and many local communities were deprived of access to the nearest town or village, which can be defined as transport exclusion.

Of particular importance for creating the phenomenon of transport exclusion in rural areas in Poland was the underdevelopment of individual motorization and the inefficiency of public transport (regional bus transport and rail transport). Before the socio-political transformation in Poland, the availability of goods such as cars was significantly limited and regulated by the state [49]. As a result, one had to wait for several years for a factory-new car, if the state had given permission to buy it. Access was mainly available to those associated with the state apparatus that exercised power and control in the country. The vehicle market was very limited. This was a common policy applied in the countries of the Soviet Eastern Bloc. It was aimed at controlling all spheres of life of the population by the State, including in particular their movement. After 1989, when it became possible to buy vehicles imported from the second-hand market from abroad, many Poles wanted to own their own car. The second reason for the significant dynamics of the growth of transport exclusion in rural areas was the failed reforms of the State Motor Transport Company (PPKS)—the main bus operator in Poland, as well as the suspension of railway traffic on local routes [50,51]. The main reason for traffic restrictions on railway routes was related to the maladaptation of the rolling stock to the volume of passenger flows. In the system of central financing of public transport, the economic efficiency of such services was not effectively verified. In the reality of the free market system, it was a challenge to maintain public transport services at the current level of supply [50].

Transport exclusion can be depicted in a broader perspective as an implication of the risk of poverty and transport inaccessibility, which can lead to transport poverty. The lack of transport affects the general lack of access to goods, services, good education, entertainment and culture and a sufficient number of social interactions [52,53]. The deficit of these factors means that people affected by such understood transport exclusion lose their autonomy, i.e., their decision-making capacity, and consequently also development opportunities. This results in social exclusion (Figure 2). Rural communities are particularly vulnerable to these processes, as they are much more affected by the negative consequences of the lack of public transport or of not owning cars. Analyses also conclude that rural residents tend to spend more on mobility than urban residents [54].

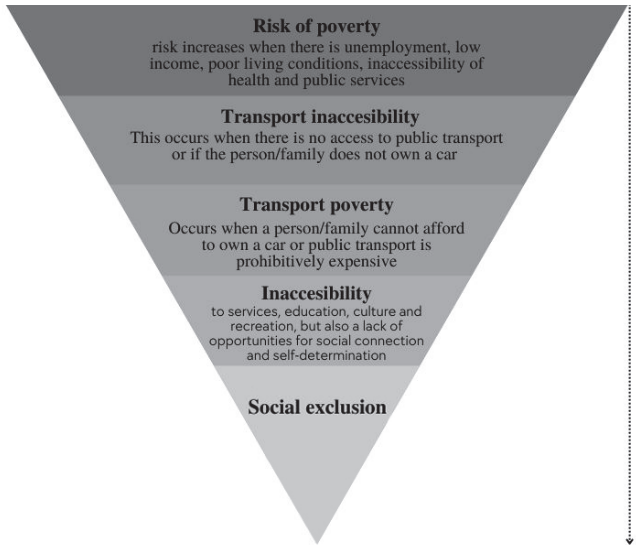

Figure 2. The relationship between a risk of social poverty, transport inaccessibility, and social exclusion (own study, based on [1–3,5,15,52,53]).

Available data shows that CEE countries are poorer than Western and Northern European countries. Data for 2005, 2008, 2012, 2016 and 2020 were taken for the analysis. Countries with unavailable or incomplete data were omitted; these included Romania and Croatia. Luxembourg, which could distort the results of the study due to its small size, was also deliberately excluded. The cumulative data is presented in a Pareto chart to illustrate the difference between CEE and Northern and Western Europe (Figure 3). Between 2005 and 2020, it was among the CEE population that there were by far more people unable to afford emergency expenses. They were therefore relatively low-income people with no financial surplus. The highest proportion of such people was recorded in Bulgaria at 77%, Latvia at 71%, Lithuania at 66% and Poland at 63%. In comparison, the countries with the lowest proportion of people without a financial surplus are Sweden at 14%, Portugal at 19%, Ireland at 23% and Belgium at 23%. Inability to afford emergency expenses correlates with the risk of poverty and social exclusion. In the event of a job loss or other sudden event, an individual or family may face poverty.

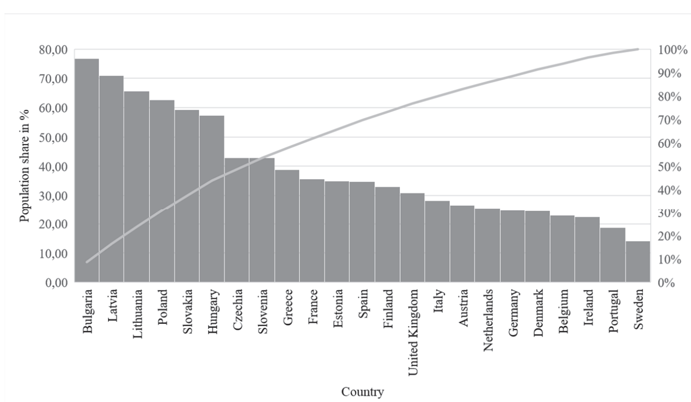

Figure 3. Share of people unable to meet emergency financial needs between 2005 and 2020 (in %) [55].

In Poland, there is a decline in public transport in regional terms—underinvestment in rail and bus transport is noticeable in reducing the number of connections or closing them [56–58]. This process is widely commented on and has become a subject of public and political debate at the national level.

The decrease in the length of operated railway lines clearly indicates a collapse of the Polish railways [59] (Figure 4). Unprofitable connections are closed down, and development can only be observed in urban and regional railways—including new international links, e.g., with Berlin. The policy of regress in railway connections appeared during the period of transformation and so-called wild privatization, when the state-owned PKP company (Polish State Railways), which is a subject managing the railway infrastructure in Poland [60], was artificially divided into several companies, including PKP Cargo (freight transport), PKP Przewozy Regionalne (regional passenger transport) and PKP Intercity (long-distance passenger transport) [19,61,62]. Along with the collapse of rail transport, there is a significant increase in interest in road transport. Numerous investments in this respect have significantly improved the conditions on Polish roads.

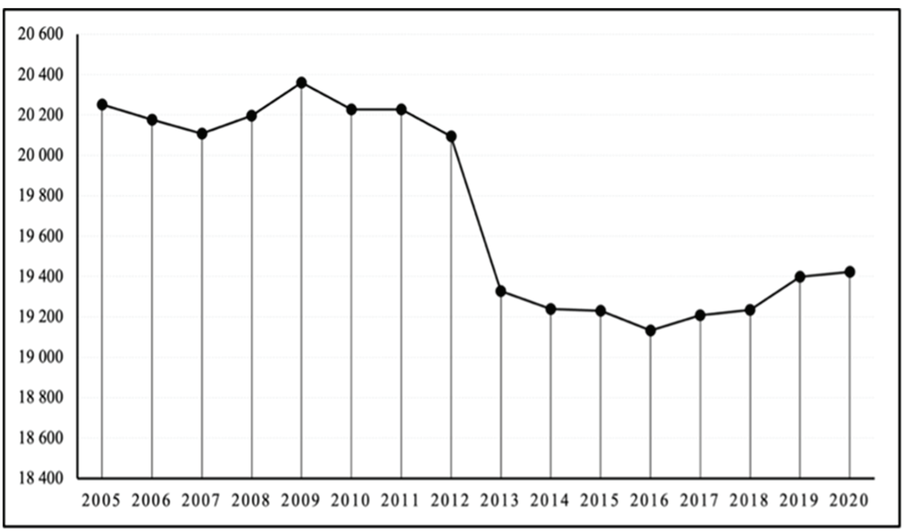

Figure 4. Length of operated railway lines in Poland in the years 2005–2020 in km (own study, based on [45]).

In 2005, only 60 percent of roads in Poland were hard-paved, while in 2020 it was almost 70 percent of all roads (Figure 5). The improvement in the surface quality and extensive modernization have contributed to the diversion of passenger traffic to roads, largely due to the phenomenon of the so-called forced motorization. A lack of alternatives in the form of rail and bus links or their mismatch with passengers' expectations has led to a significant increase in the number of passenger cars. This intensifies a phenomenon of congestion, especially in cities and in highly urbanized (metropolitan) areas.

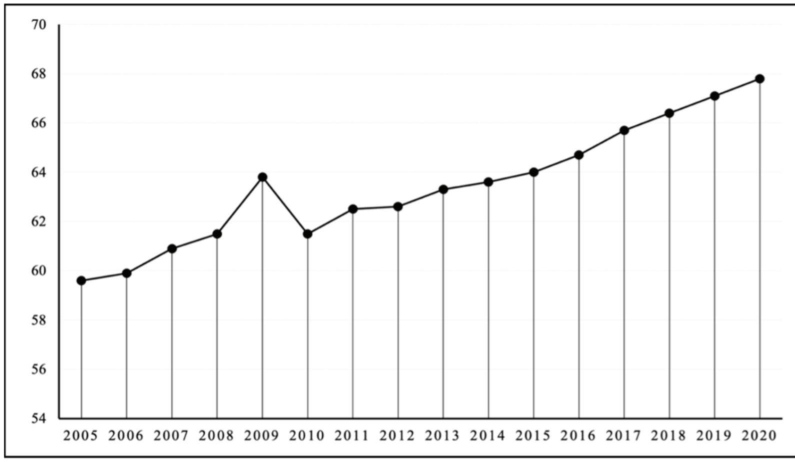

Figure 5. Hard-paved roads in Poland in 2005–2020 in % (own study, based on [45]).

Transport exclusion has a negative impact on local communities: it generates additional costs of maintaining an individual means of transport, contributes to the exclusion of some people from social and cultural life, and may also be a cause of unemployment or of a lack of access to public services.

In Poland, it is much easier to get to work by one's own means of transport than by public transport (Figures 6 and 7). Only urban transport can be an example of well-functioning public transport, while in the rest of the country travel to work is more efficient by car. This is mainly due to the lack of adequate rail and bus connections and the poor quality of offered services. The situation regarding access to the place of education or health care centers is similar. Transport accessibility is much worse in less urbanized areas, where the offer of services is linked with access to a bus or train stop as the main determinant of the choice of public transport [63,64].

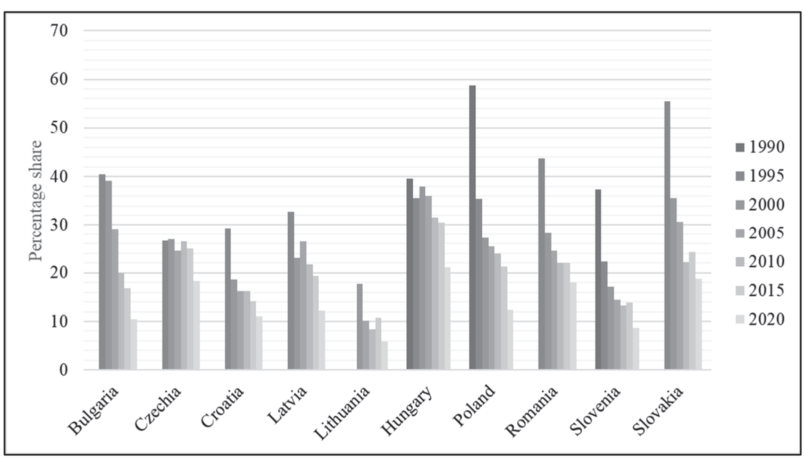

Figure 6. Passenger transport by public transport (trains, motor coaches, buses, and trolley buses) [55]. Data on public mass transit passenger transport between 1990 and 2020 was analyzed. Passenger transport by public transport in CEE countries has been steadily declining. During the system transformation, the highest share of passenger transport was recorded in Poland, at 59%. However, by 2020 it was already 12%. The same is being observed in other CEE countries. The decline in passenger transport by public transport is almost halved or more (Poland).

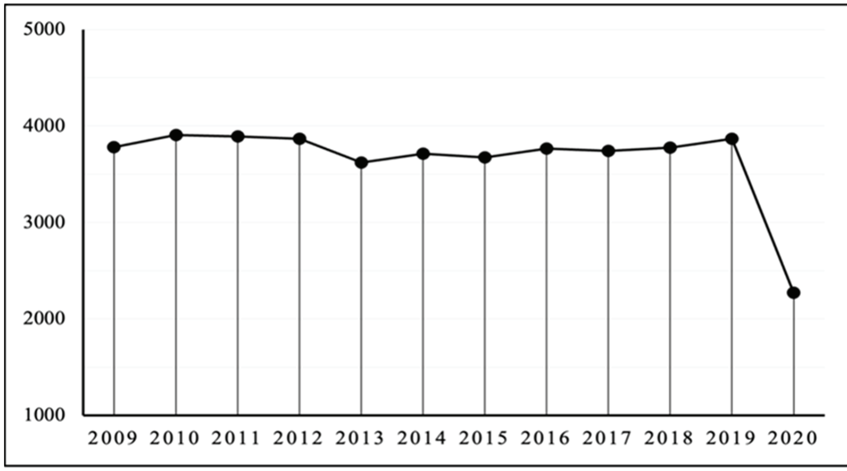

Figure 7. Passenger transportation by urban public means of transport between 2009 and 2020 in Poland in millions of people (own study, based on [45]).

4.2. The Issue of Transport Exclusion of Rural Areas in Poland

Nowadays, one can observe an increasing interest in the issue of rural development. In Poland, accession to the European Union in 2004 was a turning point. Until then, the policy had focused on the modernization and development of the agri-food sector, but in recent years more and more attention has been paid to rural development in the spatial sense. Therefore, the village ceases to be perceived as a place with typically agricultural functions. Departure from the agricultural character of rural areas broadens the typical concept of development of these areas due to the complexity of rural space [65]. Therefore, the policy should be flexible and responsive to the needs of different groups of stakeholders.

The distribution of the spatial structure of Poland indicates the dominant role of rural areas (Figure 8). Studies of the typology of Polish functional areas take into account the division of regions due to access to cities by means of transport [66–68]. If the travel time to the nearest urban center exceeds 90 min, then such rural areas can be classified as areas requiring aid in development processes [69]. Analyzing the degree of urbanization in Poland, one can see that it is strongly historically conditioned [70].

During the transformation in Poland at the turn of the 1980s and 1990s, many villages lost their significance. This led to a social collapse, followed by a reduction or closure of public transport links, which only exacerbated the negative effects of the transition to the market economy [70]. Currently, highly urbanized—metropolitan—areas play a significant role [71,72]. They are characterized by a network of interdependencies between several cities which are connected by the common market of labor, education, trade, and services [73,74]. A growing process of suburbanization can be observed around metropolitan areas, which is also associated with a change in the landscape of rural areas [75,76].

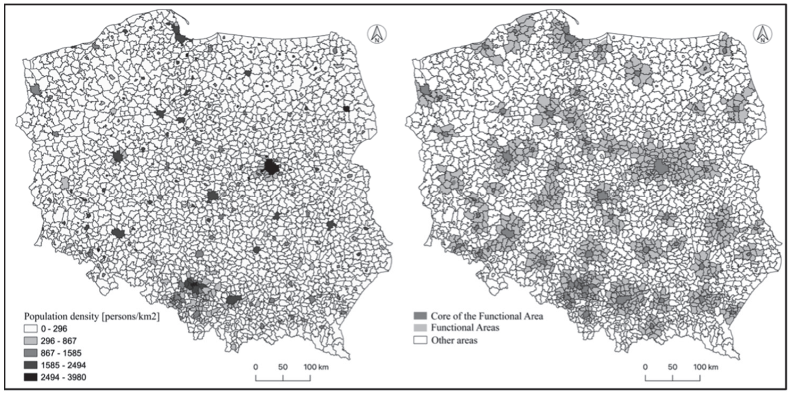

Figure 8. A map of spatial distribution of population density in 2019 and impact zones of urban functional areas in Poland (own study, based on [45,72]).

In 2021, 40 percent of the population lived in rural areas [77,78]. This results from a much greater dispersion of population than in urban areas, which is one of the most important causes of problems of local communities [78]. In 2016, in Poland, 5.5 percent of the rural population over 16 years of age did not visit a doctor due to lack of transport, and 27.9 percent of people living in rural areas are at risk of poverty and social exclusion [78]. The characteristic element of transport exclusion is not the distance between the analyzed places and cities, but the interdependence of road infrastructure, economic costs of transport, frequency of trips and its availability [78].

In 2010, Ustawa o publicznym transporcie zbiorowym [Eng.: Act on Public Collective Transport] [79] was adopted, in which local governments were obliged to develop a Sustainable Development Plan for Public Transport, commonly referred to as a transport plan. Despite this obligation, not all local governments prepared such plans [80]. Moreover, the amendment to the Act of 2018 did not lead to a real change in the availability of public transport in rural areas. Such a situation results, among others, in an increasing number of passenger cars and deepening social exclusion mainly affecting people with low incomes and elderly persons [81]. In consequence, this leads to forced motorization, also called transport poverty [82]. It is a situation in which having a car is necessary to meet the basic needs of a family while simultaneously absorbing a much larger part of the household budget than the family is able to spend on it. Thus, these are people who would use public transport if they had the opportunity.

The largest decrease in transport in Poland concerned bus transport lines on a regional scale (Figure 9). In practice, this was the main cause of the collapse of extra-urban bus transport and the cutting off of the smallest villages from any form of public transport. It was, therefore, replaced by private cars.

Railways is a mode of public transport which despite the closure of connections still operates relatively well; its importance is highest in the Pomeranian Voivodeship. In 2020, 37.3 million people used this form of transport [83]. Almost 80 percent of all transport is made by Fast Urban Rail (PKP SKM), which, however, concerns transport within the Gdansk agglomeration. Electrified railway routes occur unevenly, because their highest density is in the eastern and southern parts of the Pomeranian Voivodeship [84].

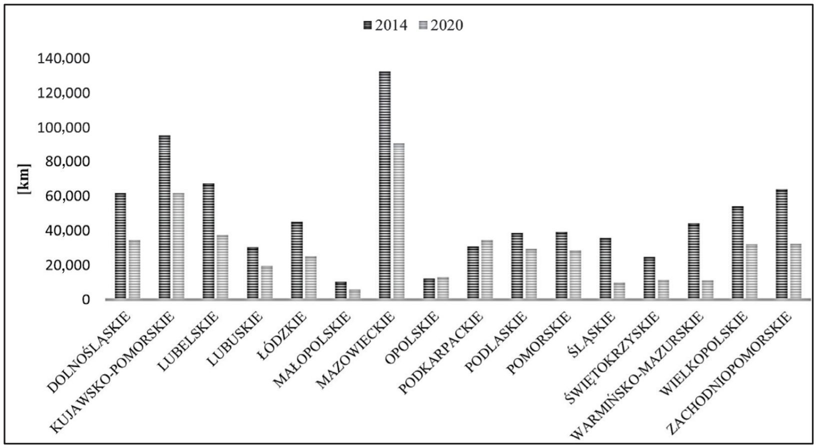

Figure 9. The length of regional bus lines broken down by voivodships in the years 2014–2020 in km (own study, based on [45]).

4.3. An Example of Transport Exclusion in Northern Poland—The Case Study of Głuszyno

4.3.1. Basic Information

Głuszyno was selected as the subject of research due to many years of participatory observations by the study authors. Knowledge of the problems of the local community and a noticeable lack of local authorities' actions inspired the authors to attempt a deeper analysis of the case. The village of Głuszyno, which is well situated in relation to the railway infrastructure, is struggling with the problem of transport exclusion, which is a rare situation, hence the need to conduct a detailed study of the conditions responsible for this situation.

The specificity of the selected case study is all the more interesting from a scientific point of view because the northern region of the country, in this case the Pomeranian Voivodeship (especially its northern part), is characterized by high spatial accessibility from the point of view of both road and rail [85]. Compared to the country, the Pomeranian Voivodeship definitely stands out in terms of the implementation of transport investments.

Głuszyno is a village located in the north-western part of the Pomeranian Voivodeship, in northern Poland (Figure 10). It is part of the Słupsk District and the Potęgowo Commune. It is a peripheral village, located between two urban centers of a regional nature—Słupsk and Lębork. It is also an extension of the development of the Gdansk agglomeration between Wejherowo and Lębork as an edge zone of the Gdansk metropolis, and Słupsk [86,87]. The demographic structure of the village clearly indicates the feminization of the community, where 51.2 percent are women and 48.8 percent are men [88]. The distribution of the population's age structure is significantly dominated by people of working age (over 63 percent), the next group being people of pre-working age (29 percent) and post-working age (over 5 percent). In terms of activity, it is a town of a typically agricultural character.

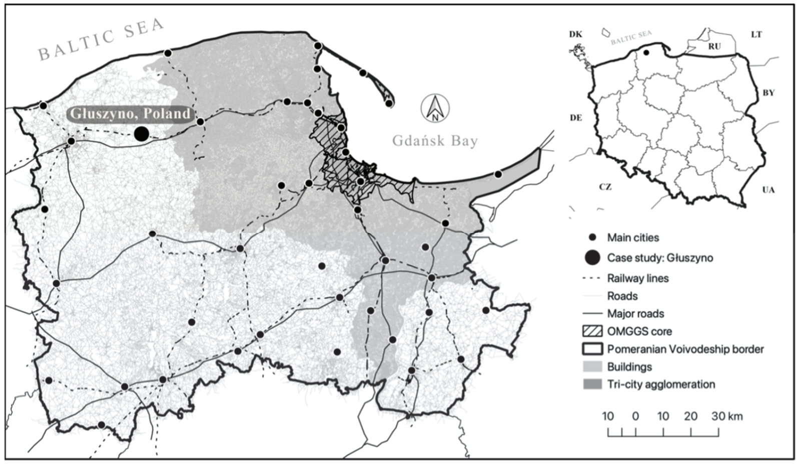

Figure 10. General accessibility to Głuszyno compared to the northern region of Poland—Pomeranian Voivodeship (own study, based on [19,26,76]).

4.3.2. Analysis of Transport Accessibility

Transport access to the village takes place in two forms—local or rail access (Figure 11). Local access takes place via a local road Głuszyno–Głuszynko (route No. III). This route poses a serious threat to pedestrian and bicycle traffic due to the lack of dedicated infrastructure. In the case of passenger cars, sharp bends and poor condition of the surface pose a particular threat. It should be noted that the distance from Głuszyno to the nearest public service center—the town of Potęgowo—is only 5 km. National expressway S6 from Szczecin to Tricity is to the south [86,89]. It is possible to access it via Potęgowo (route No. IV), so the analyzed place is located near a supra-regional transport corridor [87]. It should be emphasized that the village, despite its peripheral location, has a beneficial transport location in comparison to rest of the commune, thanks to being situated in the vicinity of one of the most important transport routes in the northern part of the country. Since 2015, the local government of the Potęgowo Commune has been providing public transport services (so-called public district transport) [90]. Activities undertaken in the field of the implementation of public transport services are not included in the strategic document which is the basic tool for shaping the development policy: Strategia Rozwoju Gminy Potęgowo do roku 2020 [Eng.: Development Strategy of the Potęgowo Commune until 2020] [91]. This illustrates a certain contradiction in the activities of the local government, as the issues related to transport, especially in rural areas, should be characterized by a high priority of intervention. On this basis, it can be concluded that the activities in this regard are undertaken fragmentarily, not systemically. The analyzed village is situated along the Potęgowo–Głuszyno–Głuszynko–Grapice–Rzechcino–Potęgowo bus route. This transport is carried out by a private carrier. It operates once a day on Tuesdays and Fridays, except on public holidays [92]. Bus transport is also realized by another carrier—PKS Słupsk. There are two routes: Głuszynko–Słupsk and Głuszynko–Lębork [93]. This transport enables a potential and direct connection with the two largest regional centers in the immediate vicinity—Słupsk and Lębork. The basic problem, however, is that in no way do these links meet the residents' transport needs related to access to public services.

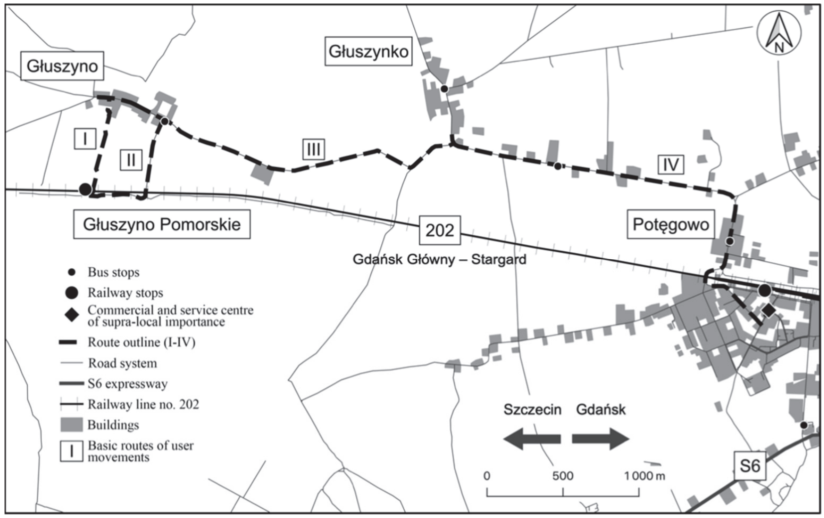

Figure 11. Road and rail accessibility to Głuszyno (own study, based on [45,92]).

The problem in the case of this access link results from the ineffective timetable of arrivals and departures which are characterized by a low correlation in terms of planning the itinerary. For example, the Głuszynko–Słupsk bus departs from this village at 7:40 a.m. The travel time to Słupsk takes over 2 h (estimated arrival time—about 10:00 a.m.). Departure from Słupsk on the same day takes place only at 10:04 and takes more than 50 min. In this case, it should be noted that this connection does not respond in any way to the basic need for efficient mobility. Another example is the Głuszyno–Lębork bus (through Słupsk). In this case, the transport is also provided once a day at 10:04 a.m. and takes over three hours. The main problem of this connection is that this transport is offered only in one direction (to Lębork), while there are no return buses from Lębork to Głuszynko. This is also an example of the paradox of designing inefficient transport connections by private carriers that cannot be linked to other modes of transport.

The inhabitants of Głuszyno compensate for the lack of good access to road transport by public and private means by using rail transport (routes I and II). This is the only form of transport that allows efficient mobility. Rail transport is also a form of "green transport", which has a low degree of negative environmental impact. The Głuszyno Pomorskie railway stop is situated to the south of the village of Głuszyno [91] along railway line No. 202. The transport provided on this route is realized on the section Gdansk Główny–Stargard Szczeciński. There are plans to expand the railway line with an additional track (the current line has only one track, and thus it is susceptible to traffic disruptions) [85]. The railway line is used both for passenger and cargo transport on a domestic west–east route [84]. Despite the noticeable willingness to develop railway infrastructure in this region, there is a process of suppressing the connection, especially on the section Słupsk–Lębork [94–97]. The main carrier operating the route is POLREGIO [98]. From Monday to Friday, this carrier's trains stop 24 times at the Głuszyno Pomorskie station (12 stops in the direction of Słupsk and 12 stops in the direction of Lębork). Comparing the presented road transport (public and private) with rail transport, there is a fundamental difference in the accessibility of both of them. It should be remembered that both modes of transport offer a different scale of accessibility and opportunities to meet the residents' needs. Road transport is characterized by the lack of a systemic approach to designing an appropriate transport schedule that would correspond to the residents' basic everyday needs in terms of access to public and private services located outside the village borders, while rail transport allows the village residents to travel much faster and on a more regular basis; however, it primarily serves to reach the regional centers (Lębork and Słupsk). Głuszyno Pomorskie railway station is located only about one km from Głuszyno. The station does not have basic facilities, for example, ticket machines to purchase of a ticket. The station is equipped with a sheet metal shelter, which is leaky and poses a danger to users. Its design does not really protect travelers from adverse weather conditions. Residents do not have access to a well-functioning bus service. They can use rail transport, but access to the railway station is difficult despite the short distance from the village center. Since this situation is unusual, the need for a deeper analysis of the special case of the village of Głuszyno should be emphasized. Transport exclusion is not a marginal phenomenon, and an in-depth analysis of the selected case may contribute to a better identification of local problems and barriers to the implementation of solutions aimed at further development of public transport.

For the purposes of empirical analysis, a field study was conducted in the form of a spatial inventory. It took place in December 2021. The study concerned a possibility of covering the route from the railway station to the village and back. The degree of accessibility of the route was checked, and the time to cover the route by persons without mobility problems and without luggage was measured. For the purposes of the study, two routes were identified: one leading through a decapitalized, cobbled local road (route No. II), and the other leading across a cultivated field, more precisely along an informal path trodden by residents (route No. I).

4.3.3. Spatial Inventory

The conducted spatial inventory allowed numerous shortcomings of both routes to be nticed. In the first case, accessibility via a local road (route II) is determined by the weather (Figure 11). With significant precipitation, it is impossible to use this route on foot, by bicycle or by car, due to the road structure. It runs under a railway overpass; in addition, it has been significantly deepened in order to allow agricultural machinery to pass under it. In the autumn-winter or early spring, this route converts into an anthropogenic watercourse, where the underpass under the railway is completely impassable due to its flooding, which is related to the layout of the nearby terrain. On average, it took over 20 min to cover the route.

In the second case, due to the conditions of the first one, the official route—a significant depreciation and a significant length of time needed to cover it—residents more often chose an informal route leading through the muddy terrain of a cultivated field (route No. I). It is also the shortest route from the village to the railway station. It takes about 10 min to cover it, but the route leads through muddy farmland. Part of the route is particularly dangerous, leading through an illegal crossing of railway tracks. The route, provisionally called "leading through the field", illustrates the classic scheme of developing space by its users who designed this fragment of space in a natural way, thus clearly indicating which route is the best for them despite numerous shortcomings related to the conditions, which include, among others, the lack of a safe and well-lit pedestrian route. Instead of the necessary infrastructure that would facilitate the residents' movement, they only have a narrow well-trodden path in the field. The presented solution fits into the classic approach of social exclusion related to limited access to public transport.

The problems of the local community of the Potęgowo commune were presented in the Social Report, which is an element of the Development Strategy of the Potęgowo Commune for the years 2015–2022 [Pl.: Strategia Rozwoju Gminy Potęgowo na lata 2015–2022] [91]. As part of building the development strategy, a survey was conducted on the residents' quality of life, in which 155 persons participated. In the conducted survey, respondents pointed to the dominant role of the passenger car as the main means of transport and described the quality of roads in the municipality as bad and very bad. It follows that the problem of forced motorization occurs in the commune and is even common due to poorly functioning public transport. However, the actions of local authorities indicated in the document focus on the construction and modernization of road infrastructure and bicycle paths, omitting activities in the field of developing public collective and individual transport.

Both characterized routes are dangerous for users, especially in the fall–winter period. They prevent, among others, persons with reduced mobility from moving safely. Despite the proximity of a railway line on which passenger trains operate relatively often, the train stop is difficult for some residents to reach. The state of the infrastructure contributes to the problem of forced motorization. The phenomenon is also reflected in local analyses of the intervention of local authorities.

5. Discussion

In the priorities and strategic objectives of the development of the Potęgowo Commune, actions aimed at counteracting social exclusion are indicated. Transport exclusion, as exemplified by Głuszyno, is one of the identified types of such exclusion [89]. However, this problem has not been adequately addressed in this strategy in terms of both infrastructure investment and social action.

Considering the information provided in the Municipal Status Report [89], investment activities in the municipality are largely concentrated in the place of its seat, i.e., the village of Potęgowo. The investment activities of the Municipality of Potęgowo are concentrated in six areas, such as the construction of heating infrastructure, road investments, construction of rural canalizations, construction of public utilities, construction of lighting and water supply systems. For example, although the investment activity of the municipality is overwhelmingly focused on road investments (almost 40% of the total investments [92]), none of the investments have been realized in the village of Głuszyno so far. In addition, based on data from the Central Statistical Office, from 1995 to 2020 there is a negative migration balance in the Municipality of Potęgowo with an average of −36 persons/year, definitely with a rural-urban and rural-foreign direction [45]. The commune is also in the lead in terms of the value of the average negative migration balance against the background of the Pomeranian Voivodeship (migration balance indicator). The long-term negative migration balance clearly indicates the yearly noticeable outflow of population from the settlements in the commune to neighboring larger cities, such as Słupsk, Lębork or the cities of the Tricity agglomeration. The main determinants of external migration are access to better quality services, satisfaction of needs (not only the basic ones but also those of a higher order), improvement of the quality of life and economic situation.

It is also worth noting that in the conducted social study, whose subject scope included the level of quality and satisfaction with life, residents pointed to the poor level of organization of collective transport or public transport and the poor and very poor quality of roads [93]. Respondents pointed out poor and too poor quality of communication services, poor and deteriorating condition of roads and difficult access to public services (e.g., health care facilities). In order to counteract this problem and to shape a sustainable village, it is necessary to take actions that should focus primarily on three key smart categories (Table 1), namely mobility, community, and prospects. Investment in these areas will generate long-term benefits:

- an increase in the quality of life of the rural population,
- development of services in rural areas (commerce, education, leisure, culture),
- development of business and attraction of new investors,
- increased accessibility to health services for rural residents,
- and increased life chances for rural children and young people

Infrastructure investment is necessary to ensure economic growth, but it is not the only factor. Equally important are (1) human resources and social participation, (2) openness, (3) ensuring legal transparency, (4) investment in other areas [99].

This model can constitute a starting point and a basis for strategic programming of sustainable rural development. Strategic planning in rural areas should take place with the support of the local community and with the involvement of all stakeholders [100]. Thus, infrastructure investments only make sense if they are preceded by a public consultation and planning process, taking into account the needs and expectations of stakeholders.

In addition to local conditions, the susceptibility of rural communities to innovation is important [101].

In terms of mobility, one should focus on modernizing the road and rail system and initiating new connections due to the poor technical condition of the local road infrastructure. It should be the responsibility of the local government to provide users with means of public and individual transport, including micromobility, for example, with the use of a system of rural bicycles (cargo bicycles). Mobility solutions based on sustainable development and low-carbon solutions should complement this. An example are eco-friendly autonomous vehicles that use alternative power supply technologies [102]. This is directly linked to the area of prospects. Actions to increase users' access to transport will result in improved access to services—education, work, health, or culture. In terms of community, initiatives should be based on actions to build a coherent and active rural community, in which participation will be an integral part affecting development activity.

Therefore, the following steps should be taken in Głuszyno. Firstly, it is necessary to fully take into account the infrastructural problems of the village in strategic investment activities and the multi-annual financial forecast of the municipality, with particular emphasis on accessibility for people with disabilities and the elderly. Secondly, coordinated planning and investment activities should be conducted for the development of a comprehensive spatial development plan for the village which would take into account alternative access to rail transport for users and promote the sustainable development of local mobility. In the scope of investment activities, the users' choice regarding the preferred route of access from the village to the nearby railway station and the residents' participation in the development activities of the local government should be taken into account in accordance with the idea of "designing by the users themselves", who themselves "provisionally" choose the best solution for them [102]. Based on the analysis of the strategic document of the Potęgowo Commune, which includes the analyzed village, it was indicated that there are no local leaders and that there is a low share of social inclusion and bottom-up social initiatives. The local government should place greater emphasis on the social activation of residents and take steps to select local leaders from among the residents of municipalities who would represent the village interests on the forum of the commune as well as integrate the rural community, since coherent rural communities are the basis for building sustainable villages. Actions to integrate the local community and stimulate social activity have an inspirational impact on the character and success of development. Activity to increase local ties and strengthen territorial identity will further consolidate this. Integrated policymakers' actions are needed to strengthen the socio-economic fabric of rural areas in terms of mobility and social inclusion. These actions should be included in analytical documents or as separate studies, for example, in the form of a mobility strategy for rural areas. Strategic studies on increasing mobility should primarily be developed at the local level in cooperation with the local community, where there are so-called white transport spots, i.e., areas that are affected by transport exclusion. Currently, European countries do not have uniform guidelines on this issue, which strongly affects the alienation of rural communities. Therefore, in order to better identify and analyze the problem situation, strategies and policies should be characterized by an individualized approach. The approach to building sustainable development based on the smart village model means not only hard investment activities, among others, in terms of improving accessibility, but also building rural identity and strengthening social ties and cooperation. The latter is necessary in the case of residents' participation and preparation by them, together with decision-makers, of a coherent vision of the development of rural areas and communities. This cooperation may also serve to prototype and test alternative means of transport which should be precisely chosen in order to counteract exclusion in a broader perspective.

In addition, actions are also needed to improve the state of development and facilities at the railway station, taking into account a new footbridge on the tracks, the location of a new shelter or a monitoring and lighting system to increase the users' safety.

6. Conclusions

The presented case study of Głuszyno fits into the classic example of a village affected by the problem of transport exclusion in CEE. This is not an isolated case, because Polish villages are struggling with a significant problem of social exclusion. This is mainly due to the process of economic transformation in the 1990s. At that time, many villages were cut off from the existing public transport, in particular bus transport, and many jobs were lost. Investments have been accumulated in areas of large cities and agglomerations [1]. This case is also special due to the fact that, despite the location of the seat of the municipality—Potęgowo—near the main transport route of national importance, which in principle should ensure good access to it, it is characterized by a significant degree of transport inaccessibility. The village has also been affected by unfavorable changes, including, above all, the lack of new investments in public infrastructure: roads, stops and parking lots. The proposed direction of rural development is based on the concept of smart villages, in which five key areas related to rural development can be distinguished in accordance with the idea of sustainable development. The aim of this concept is to improve the inhabitants' quality of life, which in the case of rural areas is often associated with improving the functioning of public transport.

Summing up the results of the research, it can be concluded that transport exclusion and forced motorization are not isolated phenomena, as they result from the poor process of shaping mobility by local authorities and gross underinvestment in public transport. In Poland, many local authorities insufficiently recognize the problem of transport exclusion and its long-term effects, which include social exclusion. The conducted field study and GIS analyses clearly indicate that public transport, although a public service, is not available to everyone. In particular, women who are less likely to have a driving license or their own car are at risk of transport exclusion and its consequences, so they are forced to use public transport, which, especially in rural areas (regional transport), is characterized by low quality, including a mismatch of the offer with the currently raised transport needs and maladaptation of vehicles for people with special needs [85]. This can only be counteracted by implementing appropriate policies and strategies at the local level, as action taken at the national level may be insufficient in view of the diversity of rural areas and their specific needs and circumstances. Rural development strategies should take into account issues related to shaping mobility, including improving the functioning of public transport (individual and collective) and shaping residents' new behaviors taking into account other forms of transport: carpooling or systems of rural bicycles.

The results of the study allow determining the causes and effects of transport exclusion and allow linking it to the problem of social exclusion. Both of these issues pose a serious threat to the development of rural areas, not only in Poland, but also in other countries, especially post-communist ones, which have undergone a transformation towards a free market economy. Rural areas are more affected by poverty (subsistence) than urban areas, as indicated by the GI–I index: the highest level was achieved by farm households [103]. Therefore, it can be concluded that rural areas currently need to be transformed towards smart and resilient villages. This was also particularly emphasized by the COVID-19 pandemic, which caused a deterioration in the quality of life of the population through significant socio-economic problems, including an increase in poverty or unemployment rates [104]. In particular, rural development should take into account the area of residents' mobility as a factor in decisions on shaping healthy local communities based on high accessibility to public services, including transport and access to a diversified labor market.

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