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Increasing the Sustainability of the Strategic Development of Oil Producing Companies in Mexico

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Abstract: In the oil industry, there is a gap between the goals of sustainable development, the implementation of oil projects and its specific consequences. Oil projects are implemented in isolation from other variables, have an insufficiently targeted impact on the territory and often have a negative impact on the environment. The purpose of the study is to improve the efficiency of oil producing companies and increase their contribution to the development of the country's economy as a whole. The methodology used in this article is based on the concept of sustainable development, systemic and integrated approaches, methodology of sub-potentials and modeling of business processes of a circular economy. The results of the study include a methodological approach to the formation of an effective business model for oil companies. We propose this methodological approach to select the projects of oil companies, taking into account economic, environmental and other factors, and the most promising prospects for Mexico. The significance of the study is that the proposed methodology makes it possible to increase the sustainability of the development of oil companies and integrate their business processes into the task of increasing the efficiency of operation and development of the territory. The novelty of the study lies in the application of the concept of sub-potentials and the calculation of critical indicator values for oil producing companies in Mexico to prevent the transition of sub-potentials of functioning and development into sub-potentials of threat and containment during project implementation.

Keywords: hydrocarbons; sustainable development goals; Mexico; circular economy; business model; PEMEX; potential of the territory

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1. Introduction

In this article, we analyze the project selection for the national oil company of Mexico, Petróleos Mexicanos (PEMEX), using a circular economy analysis of its business processes. This article presents the hypothesis that there is a gap between the sustainable development goals identified in the national oil sector planning and the implementation of oil projects in Mexico that limits the adoption of sustainability evaluation in the business process of the national oil company.

1.1. General Characteristics of the Problem

We find that the gap between sustainable development goals and the implementation of oil projects exists because business processes to select oil projects focus on the short-term relation between production and budget. This means that the short-term projects are more readily financed, to the detriment of projects with potentially greater value, such as ecological projects, which require more time to be implemented. In this paper, we argue that the main factor in generating this suboptimal outcome is the planning focus towards less efficient projects in land and shallow waters. Several factors, like the COVID-19 pandemic and the geopolitical changes in the oil industry, influenced the gap between results and national planning. Mexico's oil sector represents one of the strategic industries of the country's national economy, which is key to its energy independence and whose revenues account for about 30% of the state budget. Figure 1 shows the dynamics of oil production in Latin America. Since 2005, production volumes in Mexico have been declining. Mexico's energy reform aimed at changing this situation. However, production volumes continued to decline.

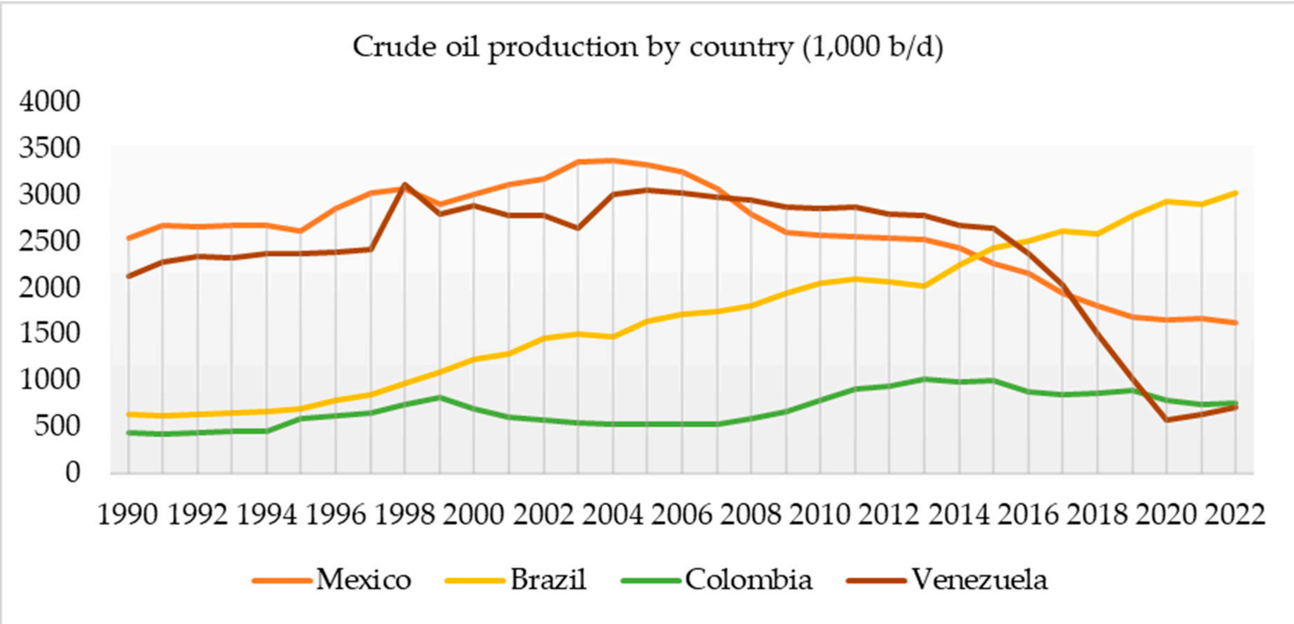

Figure 1. Crude oil production by the biggest oil producers in Latin America between 1990 and 2022 (1000 b/d), data from [1].

The 2013 reform in Mexico increased the participation of private companies (following the Brazilian model) whose oil production is growing [2]. However, this did not change the downward trend for Mexico.

To examine this contradiction between the sustainable goals and actual policies, we assess the environmental and economic drivers of oil exploration in Mexico, analyzing projects being developed by the Mexican national oil company PEMEX and private operators. PEMEX represents 96% of Mexican production of oil, and for this reason we chose a circular economy business process analysis approach. Business models in the context of circular economy aim at creating long-term economic efficiency by embracing synergies and managing risk from economic, environmental and social dimensions [3]. With the energy reform of 2013, PEMEX, the national oil company of Mexico, went from being a decentralized public organization to a productive state company. In 2019, the company also carried out a simplification of its business model to reduce the number of subsidiaries [2]. In this article we examine three cases of PEMEX exploration and production projects. In general, the problem underlying this study applies to both the level of a company and the regional level, and also relates to problems of the oil industry development.

Currently, the strategic development goals of the industry are not being fully achieved. The formation of new methodological approaches in this area is required. At the same time, it is necessary to take into account existing approaches to ensuring sustainable development of oil enterprises. Table 1 provides an overview of the main approaches in this area.

Table 1. Review of alternative approaches to study the sustainability of oil companies.

Approach	Strengths	Limitations
Resource-Based Theory	The reduction in the environmental impact of a company as a valuable internal resource for the operation of a business [4].	Resources and capabilities depend on the region
Management techniques at a planning level	The bidirectional relationship between their components and their results [5,6].	Subjective valuation of parameters
PVAR method	Al development and consumption of energy intensive goods; in contrast, renewable energy has a unidirectional causality with emission [7,8].	Data availability for short term studies
Lean production tools	Resource efficiency in the manufacturing processes improves the speed, flow and cost of a process; its tools are used to assess the impact of waste on the production process [9–11].	Microeconomic level conclusions
The stakeholder theory and the Social License to Operate	The business structure of Corporate Social Responsibility serves as a tool for conflict mitigation strategy in local communities [12,13].	Information is key in stakeholder
Spatial analyses	Multidimensional and regional outcomes [14,15].	Data availavility, experimental model in social sciences

This article proposes a methodological approach that integrates the company's business processes, the concept of sub-potentials and a systems approach that can establish the threshold for the efficient functioning and development of these projects in terms of the sustainable use of resources and the environment. We elaborate on our previous methodology of sub-potentials [16] and systemic approaches [17] to study the project selection within a national oil company in order to answer this research question: Why does the Energy Sectoral Plan of Mexico not include specific ecological indicators, and concentrates only on questions of finance and hydrocarbon reserves, if the sustainable goals are deemed to be an important part of national oil strategy? This approach seeks to alleviate ongoing issues related to the optimization and growth of the national economy.

1.2. Distiction between the Authors' Methodology and Existing Approaches

We adopt a systematic approach to ensure the sustainable implementation of projects, which allows us to simultaneously consider the development needs of enterprises, territories and the country as a whole at different levels [17]. This is especially effective for solving the environmental challenges of the oil sector, since they have significant externalities. It must be taken into account that an effective solution to these problems leads to positive effects. Typically, in the literature, environmental issues are considered only in terms of their negative externality effects.

The methodology presented in this paper integrates the tasks of economic, social and environmental development of not only oil producing enterprises themselves, but also of the oil and gas industry, and the country as a whole, utilizing the concept of sub-potentials, which allows us to consider environmental problem solutions not in isolation, but in the context of increasing the functioning and development in an integrated manner. The term sub-potential was coined by one of the co-authors of this article, offering a new approach to analyzing the environmental issues in the context of the economy of a country.

It is necessary to implement an integrated approach when selecting projects in order to ensure the sustainable development of oil producing enterprises, as demonstrated by an integrated system of indicators. In addition to economic indicators, the authors consider environmental and social factors as well. It is important to emphasize the relevance of the methodology used in this work, since the results of an analysis of Mexico's strategic documents on oil development indicate that the goals set are not always achieved.

Additional development is required in the field of these techniques and methodologies. In both the field of ecology and economics and management, the methodology utilizes a process approach because it is the most effective and consistent with international standards.

In contrast to the established approach, in which business processes are viewed in the mode of current functioning, the authors' approach allows us to consider both the present and future development processes of enterprises in dialectical unity.

Thus, the novelty of the authors' approach is as follows:

1. The need for comprehensive consideration of various factors and integration of environmental policy into a unified strategy of environmental and economic development is substantiated to ensure the efficiency of business processes of oil producing enterprises and sustainable development of territories.
2. The development of a methodology for forming a business model for a sustainable oil producing company in Mexico and its integration into the development strategy of the oil industry based on the concept of sub-potentials.
3. A methodological approach to identify priority projects in order to implement the environmental and economic strategy has been proposed; the priority of offshore oil production projects has been established to increase the potential for the functioning and development of the industry and territory.
4. Sustainable threshold values of indicators were measured to determine the boundaries of the transition of the sub-potentials of functioning and development into the sub-potential of threat and containment during the implementation of projects at oil producing enterprises in Mexico.

2. Literature Review

With this study we aim to contribute to the discussion of the relationship between development and sustainability in the extractive industries [18]. Since we identify a gap between the country planning for the oil sector and the results of the national oil company PEMEX, we focus not only on the existing business processes but on the environmental components that can complement country planning and drilling projects in Mexico. Extractive companies face a challenge to balance their development objectives with the goals of resource and environmental sustainability, as presented in the literature.

In contrast to the established approaches, according to which business processes are actually considered in the mode of current operation, the approach used in this paper allows us to consider the processes of current functioning and future development of enterprises in dialectical unity.

In the first part of the review, we present the problem for oil producing countries to achieve global goals of sustainability and the transformations they initiated. In the second part, we study the approaches for analyzing sustainable transformations within oil companies. In part three, we examine the sustainability management opportunities for Mexico's oil industry. In current conditions, a systematic review of the literature is necessary. When managing the strategic development of oil companies, it should be taken into account the actual trends and timely adjustment of the strategy.

2.1. Analysis of the Problem of Ensuring Sustainable Development of Oil Companies

Private and state companies alike slowly adopt sustainability objectives, despite the fact that the leadership of these companies has internalized the need to transition to cleaner and diverse business models [19]. Sustainable priorities in energy country planning are secondary to subjects like the energy control system, strategic collaboration and technological capabilities [20]. The specific case of the oil sector still does not consider innovating and investing in renewable energy as a core priority [21]. In consequence, international companies remain at the early stage of adaptation to sustainable practices and PEMEX is not the exception.

Sustainable development planning for the oil industry takes into account economic, social and environmental aspects. The concept of sustainability can be defined as the economic activities that meet the needs of the present without compromising the ability of future generations to meet their own needs [22,23]. Countries set goals for 2030 to meet a series of 17 sustainable development goals (SDGs) and transform their economies to achieve them. Previous experience with the Millennium Goals had been successful as a global commitment in different areas of development. The compliance with SDG monitoring at a company's business process can incorporate factors like the SDG acknowledgement and prioritization within the company, the position of investors and variables concerning the financial solidity of the company, like operating revenue and debt-to-equity ratio, which can be studied in a regression model [22].

From a critical perspective, the path towards the concept of sustainability requires a deeper transformation of countries and companies [24]. Evidence from panel data from 41 countries from 2015 to 2021 shows that the negative effect of geopolitical risks is present in resource-rich countries, a period with several geopolitical disruptions. This poses a scenario for 2024 in which it is more difficult to achieve these sustainable development goals by 2030 than originally planned [25]. Also, the benefits from economic complexity for the development of a sustainable energy sector are often diminished by geopolitical factors out of the control of planners [26]. As presented in the Materials and Methods section, Mexico's Energy Sectoral Plan was affected by the recent global changes in the oil market.

The relation between economic effectiveness and sustainable development can be summarized as one of opposing trends of short-term shocks in oil production on the stable growth of the sustainable development indexes [27]. Augmented investments in technology and ESG initiatives exhibit favorable impacts on energy efficiency both in the short and long run, underscoring the importance of strategic investments in progressive technologies and sustainable ventures [28]. Dimensions related to economic progress tend to worsen the ecological indicators, but renewable energy, trade globalization and technological innovation lessen the ecological footprint [29].

Resource-rich countries like Mexico implement changes at a slower rate because of the relevance of the natural resources rent to finance their public spending. Rents from the oil industry significantly contribute to environmental deterioration through rising ecological footprint, though they are a key element of the national planning of oil-extracting countries. Using a least squares model with 10 oil-exporting African countries, researcher Onifade finds a gap between the rent obtained from natural resources and the progress in specific ecological SDGs [30]. A recurring theme concerning the mining rent is the "paradox of plenty" when resources-rich countries suffer from a slowdown in economic, social and ecological development [31]. Foreign direct investment and ease of doing business tend to increase oil rents, when studying the resource blessing hypothesis. But oil rents further reduce financial sector development when the levels of open trade indicators increase [32]. Organizational and managerial tools can mitigate this slowdown. Countries are moving towards a more active role of the state in planning the sustainability of their extractive industries and can profit from these managerial tools at state level [33]. However, the oil sector is starting to move towards sustainability more effectively than other extractive industries; oil rents had a positive effect on decarbonization, whereas coal rents had a negative impact on environmental inclusion, as measured with an asymmetric autoregression model for the period from 1972 to 2019 [34].

Business processes that represent a support character for the oil industry are relevant as oilfields are located far from infrastructure connected areas [35]. Also relevant for the sustainability of the business model of the oil company is the optimal [36] and clean management of the transport support system [37], as well as the integration of these pipelines with other companies of the value chain [38].

Innovation also plays a key role in transforming the business structure of companies towards sustainability [39]. Innovation based on human resources and finance have a positive and significant effect on SDG compliance [40]. But, relevant to Mexico and to PEMEX, are the R&D investments carried out by government institutions; among developed economies, these investments in renewable energy reduce CO_2 emissions [41]. Jarboui et al. study 53 US companies, many of the operation in the north part of the Gulf of Mexico. These companies were able to curtail CO_2 emissions by 23%, but these emissions reduce the overall efficiency of the company in the 2000 to 2022 period [42].

The effects of global shocks on the sustainability indexes of mineral markets reveal the cyclical nature of these industries, and investments in transformations towards sustainability in this industry weaken in periods of low prices and disruptions in the market value chain [43]. Investments in the oil industry, in particular in the sustainable components, diminish due to the uncertainty of oil prices [44]. The recent global shocks to the oil industry can be measured though a triad model of sustainable development: the regulated balanced development where the social and economic spheres and the biosphere are not opposed to each other but develop in a balanced way and are not competing goals [45].

2.2. Approaches to Study the Sustainability of Business Models in the Oil Industry

Business modeling is associated with the identification of existing business processes. The concept of Sustainable Business Models in the literature integrates the challenges of addressing multiple stakeholders, the creation of economic and social value and a long-term perspective [46]. Companies are the operating unit of a system to transition to more sustainable economic outcomes because they are the places where business process changes occur. For the success of a modern oil production company, an important aspect is their development and design of new business processes [47]. The literature does not sufficiently reflect the relationship between ensuring the efficiency of business processes and sustainable development of both enterprises and territories.

The United Nations sustainable development goals (SDGs) can be used to formulate indicators to evaluate these business processes [48]. In this article we choose a reference method to evaluate projects based on the deviation from a reference point. Our analysis diverges from existing studies as we conduct an analysis of projects selection to determine their optimal sustainable operation rather than only about microeconomic trends of the oil industry. An alternative systemic approach to study the sustainability of a company is the Resource-Based Theory. The reduction in the environmental impact of a company as a valuable internal resource for the operation of a business [4]. Other approaches based on management techniques exist at a planning level within the companies, like the McKinsey's 7S framework, the business model canvas and the strategy diamond [5]. A challenge for estimating the effect of circular economy models is the bidirectional relationship between their components and their results [6].

An alternative method to estimate the bidirectional relation between sustainable indicators and the financial and operative elements of an enterprise is the Panel Vector Autoregressive (PVAR) method; to trace this effect over a period of time [49], impulse response functions can complement the results. Researchers Dutta et al. examine the influence of financial development of countries, as an indicator of technological adoption, to achieve sustainable goals. They use the PVAR method to account for the endogenous interaction and the possible bidirectional relationship between these two concepts [7]. Adding to financial development, researchers Usman et al. explore the role of consumption of energy intensive products in the aforementioned relation. They find a bidirectional causality exists between greenhouse gas emissions and financial development and consumption of energy intensive goods; in contrast, renewable energy has a unidirectional causality with emissions [50]. This bidirectional relationship can be also estimated of financial shocks on sustainability. Researchers Zribi et al. examine the relation between uncertainty, investor sentiment and environmental performance, but they find a weak bidirectional relationship [8]. We do not use the PVAR model in our research, given that the nature of our data has a limited time interval and the object of study of our article is production projects. Limitations of the PVAR methods consist in the number of observations needed for a confident estimation.

Management tools can improve the sustainability and effectiveness of oil companies through an effective allocation of resources. Lean production tools include key performance indicators and Six Sigma [9]. Resource efficiency in the manufacturing processes in the energy industry must identify novel working procedures or methodologies; green Lean production and a circular economy are new fields of interaction [10]. Lean Six Sigma focuses on the speed, flow and cost of a process, and its tools are used to assess the impact of waste on the production process [51]. Industry 4.0 technologies have been incorporated into manufacturing, augmenting the effect of Lean methodology [11,52].

The stakeholder theory and the Social License to Operate can be used to study sustainability in oil companies. These companies adopt Corporate Social Responsibility with the aim of continuing their commercial interests, while addressing harm from production. Also, the business structure of Corporate Social Responsibility serves as a tool for conflict mitigation strategies in local communities. But, there is weak evidence that these business structures facilitate oil production and they are rather disconnected from company goals [12]. Limitations of this approach consist in the experimental nature of knowing the stakeholder preferences [53]. Coronado et al. also have conducted an institutional analysis of the public organizations related to the management of fisheries and oil production on the Gulf of Mexico [13]. During our analysis of the Sectoral Plan in Mexico, we detected the absence of this analysis regarding the ecological indicators in the plan. We incorporate some elements of this stakeholder theory and the Social License to Operate in our analysis in 4.1 through a point method evaluation of the stakeholders involved in reducing the ecological impact of oil activities in Mexico.

In this article, we build upon the concept of sub-potentials of reproduction, defense, management and reserve. Sustainability measurements have evolved to study limited territories [17]. In a previous study, we based our analysis on this conceptual framework to define the concept of potential of the potential for the functioning and development of the territory [16].

An alternative method is explored in the research by Banacloche et al., who find that investment in carbon capture technologies in Mexico allows a net reduction in the carbon emissions. They use an environmentally extended multi-regional input–output analysis; this is a business model analysis that links inputs and outputs of production and residues in the life cycle of an industrial process. The researchers study the factors around the development of natural gas production in the Mexican policies for the period 2020–2050 [54]. Spatial analyses for the sustainability in a territory are an emerging trend in the literature [14,15,55]. They integrate different dimensions to establish the optimal balance of factors in a region.

The concept of sub-potentials allows us to consider the business processes of an enterprise in the unity of functioning and development. In order to maintain the functioning of the company at the same level, it is necessary to invest in effective projects in the present time. At the same time, the implementation of investment projects ensures increased efficiency of the business development processes. When implementing insufficiently effective projects or with insufficient consideration of factors, including environmental ones, the sub-potentials of functioning and development can turn into sub-potentials of threat and deterrence.

2.3. Sustainability Management Opportunities for Mexico's Petroleum Industry

Around 76% of oil extraction in Mexico is carried out in the Gulf of Mexico, a place with areas of high biodiversity and fishing production. But, there is an imbalance in decision-making between the economic, environmental and societal dimensions for this region. Researchers Coronado et al. find that the policies of the Mexican government give privilege to economic development and infrastructure goals (SDG 8 and 9) rather than food security and gender (SDG 2 and 5) [13].

The major oil and gas enterprises in Latin America started to comply with the sustainable development goals, in particular numbers 7, 9, 11 and 12. Analyzing the reports of these companies, Borges et al. found that Latin America started to better integrate financial services, encourage sustainable practices and add sustainability information in their reporting cycle, and started to rationalize their inefficient fossil fuel subsidies [56].

Structural trends that limit Mexico's ability to effectively incorporate sustainable management can be defined as follows: (1) institutional inertia due to access to a vast oil and gas resources in the past, displacing clean energy technological niches; (2) reduced investment in clean energy research, development and innovation; (3) policy focus on the societal needs and socio-political interests in favor of cheap fossil fuel power generation [57].

But the dynamics of sustainability in Mexico point that economic growth is directly related to fossil fuel energy use, urbanization and tourism, which increase CO_2 emissions in the country, while increased renewable energy use and agricultural productivity help to improve the environmental quality in Mexico by reducing CO_2 emissions [58]. In current conditions, it is difficult to ensure sustainable development of PEMEX [59,60].

The literature in Mexico has taken production data and economic data as a source without linking them to oil projects and specific sustainability variables available in the results reports of the PEMEX company. The company measures spills and emissions in its reports. This information can complement the analyses that have been carried out on the Mexican market. We conducted an economic and ecological analysis based on the project's passports. The literature presented that the opportunities to evaluate oil projects are the constant ecological risks of these activities. These are emissions and low-scale oil spills, variables which will serve as a framework to define the sustainability of these activities [61].

On a social aspect of sustainability, safety performance evaluation, comprehensive employee training for effective human–technology interaction and the seamless integration of sustainable development principles into operational aspects of oil companies improve the performance of the company [62]. Concerning innovation, within PEMEX, each of the agents involved in the development of the organizational culture of the company have completely different perspectives on the level of innovation expected in PEMEX [63].

On the consumer side of the post-energy reform scenario, price elasticities concerning the consumption of energy, gas, gasoline and food were affected by the increase in energy prices in the years after the reform in Mexico. This also led to a reduced consumption of energy generated with fossil hydrocarbons, but that affected the portion of the population with less income. In terms of sustainability, it has not fulfilled the promise of access to affordable energy for all [23,64]. Another social aspect affecting PEMEX is the nexus between organized crime and oil theft [65]. This theft affects the security of the pipeline infrastructure and the workers of the company [60].

The sustainability of reserves in Mexico is one of the priority issues of the country's administration. Although new discoveries in deep waters are required to increase the reserves [66], they are considered to be a costly undertaking. The complexity of offshore oil projects, including financial, technical, climatic and infrastructure, necessitates long-term investment and development conditions. Subsoil exploration has an anthropogenic effect on the environment that can be studied through the modelling of wells [67]. Wen et al., by studying current trends in deepwater exploration, find that companies must use technology to reduce the costs of further activity by transiting to expand the sources for obtaining multi-user seismic data to first improve the scientific selection of deepwater exploration areas; second, increase efforts to obtain deepwater exploration projects in key areas; third, work with governments for licenses flexibly; fourth, acquire licenses with large equity and operate in a "dual-exploration" model; fifth, strengthen cooperation with leading international oil companies in deepwater technology; and sixth, improve business operation capabilities and gradually transform from "non-operators" to "operators" [68].

The management of marine oil spills, in particular of accidents due to subsea oil pipeline leaks which are a constant in the industry, is moving to probabilistic models of management [69]. Likewise, part of sustainable management must consider the management of polluting accidents of mineral extraction. In the context of offshore resource extraction oil spill response tools are a key component of planning for countries and oil companies [70]. Seismic and subsoil data of oilfields also are a relevant measurement to forecast oil spills and to prevent unnecessary exploratory drilling [71]. Microbiological remediation on land is an alternative to solve the effects of these spills [72], and also biomass for algae can be used for this purpose [73], though on water this method still faces effectiveness challenges. But also, waste from normal drilling activities has a negative effect on the environment if not managed properly [74,75]. In the present article, we substantiate the importance of solving environmental problems from the point of view of increasing the sub-potentials for the functioning and development of the country's economy. In the literature, the traditional view of environmental activities is associated with significant costs, which reduce the possibilities of economic development.

Mexico is expanding its refining capacities to address changes in its increasingly manufacturing-intensive production structure. The country faces the challenge of adjusting its refining program to new trends in this research agenda: high-value petrochemicals and heavy oil refining. High demand for petrochemicals indicated a predictable growth in recent years, mainly driven by the commodity product requirement [76]. Likewise, refining is adapting its processes to cleaner procedures, with better recovery of raw materials and better reuse of waste.

In summary, our research proposes a framework integrating theoretical insights from sustainability definitions, specifically within a corporate context. That is why we use a business model approach. This approach will be used to evaluate projects. However, the conclusions drawn will be at country level, considering that the oil company is the largest producer in Mexico. Furthermore, our sustainability analysis will encompass insights derived from benchmarking, stakeholder theory and sub-potentials calculation.

Limitations of existing research and related objectives of this study consist in the following:

1. Identification and consideration of contemporary factors in the development of oil producing enterprises in Mexico, taking into account the opportunities and limitations of the industry and region.
2. Formation of a business model for an oil producing enterprise in Mexico along with its integration into the development strategy of the oil industry.
3. Development of a methodological approach and selection of a strategy for the development of the oil industry in Mexico.
4. Establishment of the boundaries of the transition of sub-potentials of functioning and development into the sub-potentials of threat and containment for the Mexican oil industry.

3. Materials and Methods

To integrate the company's development processes into the territorial strategy for environmental and economic development and increase their efficiency, it is necessary to study planning documents at the country level. In this section, we present an analysis following the next steps: Firstly, an analysis of the Sectoral Energy Plan for 2020–2024. It is necessary to determine whether sustainability indicators are included and to what extent the indicators can be used to evaluate projects. The authors' approach to solving the problem of ensuring sustainable development includes the use of a process approach and the concept of sub-potentials.

Secondly, we examine through a point reference approach the sustainability threats of oil projects in Mexico. Company data about yearly spills and emissions give us a basis to include planning indicators that are not included in the national planning that can determine the sustainability of the energy policy, and subsequently the projects made within the country.

Thirdly, we examine the selection of oil projects in exploration and production, presenting a reference method model. These projects were selected because they have open data and a sustainability analysis made by the national investment bank of Mexico and the international organization Interamerican Development Bank. Therefore, we can combine economic and ecological indicators to make a choice of the most effective project in both areas.

Finally, we examine the defense sub-potential for the selected project using the anthropogenic pressure index to correlate constant oil spills from extractive activities to the area of the selected oilfield.

3.1. Establishing the Methodological Approach to Sustainable Business Processes

When managing an enterprise, functional and process approaches are implemented. Upon analysis, we concluded that for oil producing corporations in Mexico, a business-process approach is more effective in contemporary conditions of the oil market of the country. Business processes are structured into sub processes of the main activity of the enterprise, infrastructure processes and business processes of management and development.

The article proposes a methodological approach that integrates the company's business processes, the concept of sub-potentials and a systems approach. In accordance with the systems approach, an enterprise is a large system which is represented in the form of subsystems of decreasing levels of complexity [17,39], adding a company-level approach to the methodology developed in our previous work [16]. The implementation of a systematic approach involves taking into account the needs and interests at the level of enterprises, territories and the country as a whole.

In order to ensure the sustainable development of oil producing enterprises, it is important that any large systems, like these enterprises, have the properties of synergy, emergence and multiplicativity. The property of synergy, that is, the unidirectionality of the actions of various subsystems, can lead to an increase in the final result, or maybe to a decrease in it. It is important to boost the final positive outcome and avert the emergence of negative synergy effects.

Within the framework of the concept of sub-potentials, the sub-potentials of functioning and development are identified, which are further decomposed into sub-potentials of reproduction, management, protection and reserve (positive sub-potentials). However, the enterprise also has sub-potentials of threat and deterrence (negative potentials). Positive and negative sub-potentials can transform into each other when certain indicator values are reached. An important task is to determine the boundaries of the transition of positive and negative sub-potentials into each other, which will make it possible to effectively manage the enterprise and ensure its sustainable development. We have set the task, among other things, of determining such transition boundaries for oil producing enterprises in Mexico.

The formation of a business model for the development of an enterprise makes it possible to integrate various sub-potentials in the aspect of integrated business process management and a target setting for a significant increase in the efficiency of the enterprise as a whole.

In order to ensure the sustainable development of an oil producing company and prevent the indicators from declining to a level that may turn out to be critical and lead to negative synergy phenomena, the defense sub-potential is considered in terms of its impact on the environmental situation. The protection sub-potential uses the anthropogenic load factor, as well as the number of emissions and spill volumes. For Mexico, the values of these indicators have been established, which determine the boundaries of the transition of one sub-potential to another.

The implementation of offshore projects has been calculated as the main reserve sub-potential for the Mexican oil industry. The calculation is carried out using the standard method, which allows the application of an integrated approach to evaluating projects, taking into account various environmental and economic indicators. As a result of the study, boundary values were established based on the use of the indicator for light hydrocarbons.

The assessment of the transition point between sub-potentials of functioning and development into sub-potentials of threat and containment was carried out on the basis of total production at sea and on the shelf. Critical values have been established for Mexico.

The management sub-potential is considered through strategic planning for the development of the Mexican oil industry. Analysis of the Sectoral Energy Plan showed that all the necessary factors for sustainable development are not sufficiently taken into account. Environmental indicators are under-represented and too general. The transition of the control sub-potential to the threat and containment sub-potential is assessed by EBITDA and the share of oil rent in budget revenues.

Since oil production projects in Mexico require large expenses, especially offshore projects in the deep sea, the selection of implemented projects using key indicators characterizing the boundaries of the transition of sub-potentials into each other makes it possible to prevent negative effects, including those related to the environmental situation. The use of such indicators also makes it possible to increase the efficiency of strategic planning and, accordingly, business processes of management and development.

3.2. National Planning of the Oil Industry

As presented in the introduction, planning at country level is defined in the Sectoral Plan of Energy 2020–2024. In this section we compare the plan to the actual results of the sector for the studied period. Firstly, we made a selection of indicators from the plan that are directly related to the oil industry. The other half of the plan concerns the electric sector. Therefore, we calculated, through the formulas established in the same Sectoral Plan, the indicator for each available year. The plan was formulated before the events of the COVID-19 pandemic and the global changes of the oil industry. Most of these trends occur at an industry level since the oil sector in Mexico is relatively closed, making it resilient to external shocks. However, we expect a debilitated realization of the plan. But more importantly, we examine the missing areas in sustainable planning of the oil sector.

For the purposes of this study, an important conclusion is that most of the goals of the strategic plan did not achieve the specified time targets. This is especially evident from the last column of the table. Thus, strategic planning for the oil industry development needs to be improved. The most important area of such improvement, according to the proposed methodological approach, is the integration of business processes of oil companies into the development strategy of the industry and territory. This will increase the efficiency of strategic development of both the oil companies themselves and the industry and territory.

An analysis of indicators was carried out based on the reports from the Secretariat of Energy. The plan contains six objectives: achieve and maintain sustainable energy self-sufficiency to meet energy demand (1); strengthen the state's productive companies as a means for national development (2); organize scientific, technological and industrial capacities for the energy transition (3); raise the level of efficiency and sustainability in the production and use of energy (4); ensure universal access to energy (5); strengthen the state's productive companies, social and private (6). These, in turn, are divided into three subgoals. From these, we select the relevant indicators for the oil sector.

We compared the goals of the Sectoral Plan to the factual results achieved by the sector in that year using the same formulas stated in the plan to calculate the present values of these indicators [77]. Of the entire set of indicators studied, the most relevant for the oil market are presented in Table 2. The first column describes the indicators of the goals related to the oil industry in the plan; the second column presents the goals of the strategy as presented in the official document, calculated during the pre-pandemic conditions; in the third column, we calculated the actual values of these goals with the available data of early data from 2024; finally, we measure the gap between plan and reality.

Sources of information for determining the current strategy values in the oil sector are as follows: the National Energy Balance for the Energy Independence Index; Bank of Mexico national oil trade balance accounts; PEMEX's EBITDA is derived from its earnings report as well as operating indicators. The cost of fuel prices comes from the National Institute of Geography and Statistics, which measures the index of consumer prices (it has been deflated to 2022 values); the pipeline transport infrastructure and reserve recovery rate are taken from the PEMEX Statistical Yearbook, and the oil revenue calculation, the government budget, was prepared based on data from the Bank of Mexico [78].

Table 2. Goals from the Sectoral Plan of Energy 2020–2024 [77].

Index	Goals Calculated Presented on the Plan Based on 2018 Data (Value)	Results Estimated by the Authors Using the Secretariat and Company Sources (Value)	Percentage in Relation to the Goal Established in the Plan
1.1 Energy Independence Index	2020: 0.75 2021: 0.8 2022: 0.85 2023: 0.91 2024: 1	2018: 0.70 2019: 0.72 2020: 0.87 2021: 0.68 2022: 0.71	2018: −0.07 2019: −0.04 2020: 0.16 2021: −0.15 2022: −0.16 2023: −0.22 2024: −0.29
1.3 Energy trade balance	2024: 0	2018: −1.8 2019: −1.42 2020: −1.13 2021: −2.33 2022: −2.24 2023: −0.16	2018: −1.80 2019: −1.42 2020: −1.13 2021: −2.33 2022: −2.24 2023: −0.16
2.1 Gross operating profit (EBITDA in MXN)	2020: 621 2021: 819 2022: 907 2023: 1106 2024: 1194	2018: 102.1 2019: 69.2 2020: 18.1 2021: 135.2 2022: 91.5 2023: 84.0	2018: −0.84 2019: −0.89 2020: −0.97 2021: −0.83 2022: −0.90 2023: −0.92 2024: −0.93
2.2 Petroleos Mexicanos production capacity growth rate (%)	2024: 162	2018: 100 2019: 93.1 2020: 91.9 2021: 101.1 2022: 106.7 2023: 101.1	2018: −0.38 2019: −0.43 2020: −0.43 2021: −0.38 2022: −0.34 2023: −0.38 2024: −0.38
3.1 Percentage of construction of production facilities for critical technologies by companies of national capital	2020: 40 2021: 60 2022: 80 2023: 100 2024: 100	Not implemented	
3.2 Number of institutions participating in the Critical Technologies Development Program	2024: 28	2018: 3 2019: 3 2020: 3 2021: 3 2022: 4 2023: 4	2018: −0.89 2019: −0.89 2020: −0.89 2021: −0.89 2022: −0.86 2023: −0.86 2024: −0.86
3.3 Number of agreements or projects included in the Critical Technologies Agenda	2024: 100	Not implemented	
5.2 Changes in fuel prices and domestic electricity tariffs in relation to the national consumer price index	2024: 1.42	2018: 0.88 2019: 1.07 2020: 1.04 2021: 1.15 2022: 1.08 2023: 0.93	2018: −0.38 2019: −0.25 2020: −0.27 2021: −0.19 2022: −0.24 2023: −0.35 2024: −0.35

Table 2. *Cont.*

Index	Goals Calculated Presented on the Plan Based on 2018 Data (Value)	Results Estimated by the Authors Using the Secretariat and Company Sources (Value)	Percentage in Relation to the Goal Established in the Plan
5.3 Differences in the scale of energy transport infrastructure	2024: 10,634	2018: 1728 2019: 0 2020: −1456 2021: 128 2022: −116	2018: −0.84 2019: −0.99 2020: −1.14 2021: −0.99 2022: −1.01 2023: −1.01 2024: −1.01
6.1 Reserve–Replacement Ratio (RRR)	2020: 83.5 2021: 84.8 2022: 57.1 2023: 46.4 2024: 100	2018: 32.4 2019: 36.6 2020: 118.9 2021: 91.5 2022: 103 2023: 102.6	2018: −0.61 2019: −0.56 2020: 0.42 2021: 0.08 2022: 0.80 2023: 1.21 2024: 0.03
6.2 Contribution of the oil sector to public sector budget revenues.	2024: 15	2018: 13% 2019: 6% 2020: −36% 2021: 17% 2022: 40% 2023: −3%	2018: −0.13 2019: −0.60 2020: −3.40 2021: 0.13 2022: 1.67 2023: −1.20 2024: −1.20

The Sectoral Plan of Energy proposes a comprehensive program of critical technologies that will be produced nationally to achieve a sovereign and inclusive energy transition. In theory, this program is based on annual milestones of expected progress in building these capabilities. This Critical Technology Project Development Plan is part of 20 annual projects and agreements. However, this plan was not implemented.

To construct the last column of Table 2, the percentage between the goal set in the strategy and the value of the variable in the analyzed year was obtained. For the periods 2018 and 2019, the goals for 2020 were compared with the goals of these two years, since the basis for calculating the Plan was 2018. For most variables, data are available for 2023; for 2024, the target value is compared to the actual value of the year in 2023.

Regarding the first goal, we see that the indicators related to the oil and gas sector were not met. In most cases, the annual incidence rate is negative. The effect of the pandemic is clear in these indicators, with 2021 breaking the trend of a narrowing gap between compliance and the plan target. The Energy Independence Index in Figure A1 of Appendix A can be interpreted as an increase in energy imports (Figure A2) due to the insufficiency of the national grid to supply the country. At the same time, oil-specific commodities continue to be negative. However, it can be seen that in 2023, under the high price scenario, this balance changes.

PEMEX's financial and productive operation addresses the second goal of the program. The state-owned company has had negative results for several years. However, the impact of the pandemic has reduced these losses in the short term. As things return to normal, the trend toward negative EBITDA continues (Figure A3). From a production perspective (the indicator measures the combined production of extraction and processing), we can also observe a violation of the set goals (Figure A4). The pandemic does not appear to have affected the overall trend in this indicator. But this leads us to ask why manufacturing trends remain unchanged even though important transformation programs have begun in extraction and refinement.

Regarding the fifth goal, we can see that fuel price changes as the estimated cost of consumer welfare follows global trends (Figure A5). Although the price of fuel is subsidized in Mexico, the subsidy only has mild changes, such as a price drop in 2020 and an increase in 2022 (Figure A6).

Regarding the sixth goal, the reserve restitution rate has exceeded the goals set in the program. The Ministry of Energy and PEMEX invested most of the efforts after 2018 to increase resources in shallow waters (Figure A7). However, it poses the question about the quality of oil in these reserves.

While the contribution of the oil sector to the state exceeded the proposed goals (Figure A8). This can be explained by rising oil prices. We see that production, measured in a combined manner, has not increased significantly.

From these planning indicators at a national level, we conclude that there is little sustainability content. The only indicators concerning reserve restitution and price monitoring of consumer energy prices attend to the sustainability of the oil industry. The Sectoral Plan considers only renewable energies for the electric grid as a goal for country planning.

But within the petroleum sector, there are several opportunities for measuring the performance in ecological variables that the company PEMEX reports annually. We will use these data to assess through point reference analysis which indicators should be taken into account for the country planning of sustainable oil projects. In Table 3, we present some of this ecological reporting as well as the budget PEMEX assigns to the Operation and Maintenance of Ecological Infrastructure. These data will serve to estimate a point method evaluation of the ecological practices of the company as a whole as a framework to evaluate projects in the oil industry in Mexico.

Table 3. Ecological effects of oil extraction and budget for ecological infrastructure in PEMEX between 2010 to 2022 [78].

Year	Leaks and Spills. Events	Leaks and Spills. Released Volume (b)	CO_2 Emissions (MMt)	SOx Emissions (Mt)	PEMEX Budget for the Operation and Maintenance of Ecological Infrastructure (M USD)
2010	154	25,824	59.9	632.2	333.78
2011	131	269	49.2	471	360.53
2012	264	39	43.4	413.3	348.90
2013	153	24,629	47.1	481.5	414.66
2014	159	511	55.6	606.9	334.52
2015	209	1164	64.9	733.0	322.13
2016	192	812	68.0	900.2	168.86
2017	223	506	49.4	654.8	180.68
2018	912	1374	46.3	648.1	91.81
2019	1092	1717	48.0	879.7	76.42
2020	931	535	65.8	1153.9	52.96
2021	1163	1079	71.1	1305.1	77.36
2022	1167	10,522	69.0	1139.6	87.74

The number of leaks and spills has been increasing since 2018. Accounting for volume, only years 2010, 2013 and 2022 registered big spills that could signify accidents out of the norm. On the other hand, CO_2 emissions have been stable, while SOx emissions increased over time. The PEMEX Budget for the Operation and Maintenance of Ecological Infrastructure has been decreasing over time (deflated to 2022 values), and the changes in the finances of the company may explain this decrease. The analysis of this table shows that it is necessary to increase the efficiency of the company's strategic planning, aimed at improving both the economic results and environmental performance indicators.

3.3. Methodology for Integrating Business Processes of an Oil Company into the Strategy of Territorial Environmental and Economic Development

It is possible to present the development potential of a national oil company in the form of sub-potentials for functioning and development, including sub-potentials for reproduction, protection, management, and reserve, as well as sub-potentials for threat and containment. We model this potential for development of a company in the form of a business model [16].

A business model is defined as a structured description of a network of processes associated with data, documents, organizational units and other objects that reflect the existing or proposed activities of the organization, as shown on Figure 2. Business management processes are processes that span the entire spectrum of management functions at each level, including both sub-processes and the enterprise as a whole. These entail strategic planning, operational planning and the implementation of management influences. Business development processes encompass the enhancement of products and services, technological advancements, equipment modifications and innovation.

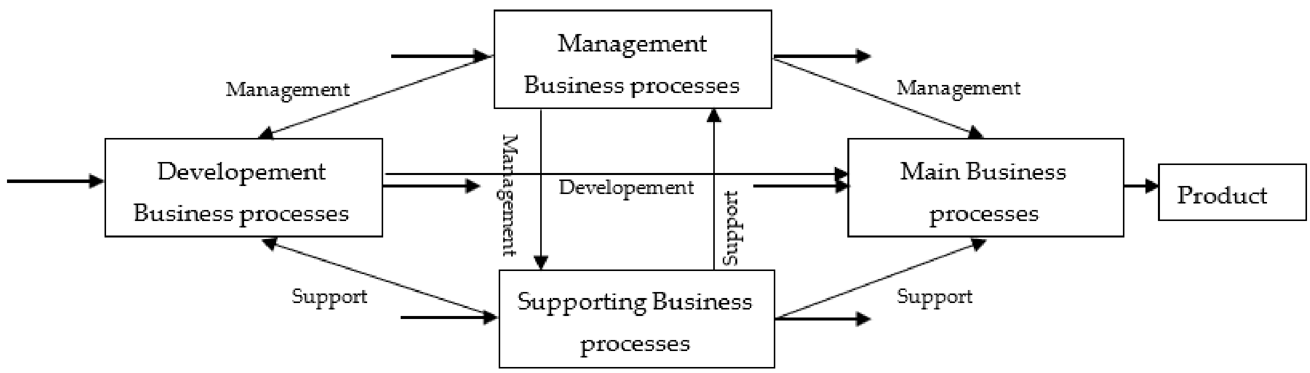

Figure 2. Enterprise business process system.

The main business processes generate the company's income. These include processes focused on the production of goods or the provision of services, which are the target areas that ensure the generation of income. Business processes that generate results and consumer qualities are oriented towards external clients and their willingness to pay. Supporting business processes are processes focused on the production of goods or the provision of services, which are the results of the accompanying main production of pro-duction activities and thus ensure the generation of income. As presented in this figure, strategic planning refers to the business processes of company management. Since achieving strategic goals is associated with the development and implementation of projects, it also relates to the business processes of enterprise development. It should also be emphasized that maintaining current performance indicators even at the same level in the future also requires development costs, otherwise the enterprise's performance indicators will deteriorate. Thus, solving strategic planning problems is key for maintaining and increasing the potential for the functioning and development of an enterprise, including their main and supporting business processes.

Oil producing enterprises have a direct impact on the development of the territory, both in terms of increasing their economic potential and influencing the environmental situation. There is also an impact on the social sphere, including the health and working conditions of workers and the population. Considering the importance of the oil industry, the integration of their business processes into the territory development strategy is required. In this case, it is possible to optimize the business model of an oil producing company.

Currently, there are significant changes in the external environment affecting enterprises across the entire spectrum of the oil sector (fluctuations in oil prices, dollar exchange rates, slowdown in the growth rate of demand for energy resources, described in the first chapter of the dissertation), and therefore oil companies require new or improved methodological approaches to their strategic development and effective management in a competitive environment of all business segments. With the development of the global oil market and the processes of oil companies, one of the urgent tasks facing modern oil companies is the development of a strategy that meets global challenges and national priorities, contributing to an increase in oil production and the growth of production of petroleum products and petrochemical products. The most significant indicator for assessing the effectiveness of a company's development strategy is its investment cost.

To achieve this, we study the sustainability of projects of the oil industry based on the concept of sub-potentials. In the concept of sub-potentials, the potentials of individual projects influence each other, increasing or decreasing the capabilities of other projects within one company [16].

The proposed methodology, comprising a comprehensive array of indicators, facilitates the creation and implementation of efficacious environmental and economic strategies, while also allowing for modifications in response to prevailing circumstances.

To model a development strategy for an oil company, it is necessary to conduct a detailed study of the market conditions of the oil market and its trends, as well as an analysis of the activities of the oil company in accordance with the existing business model and its strategy. An oil company's potential can be represented as a system of sub-potentials for functioning and development, which, in turn, include four sub-potentials: reproduction, defense, management and reserve.

Based on the fact that the main strategic goal of an oil company is to ensure the growth of its investment value through its projects, the main strategic goal of an oil company is to ensure the growth of its investment value. The choice of business model depends on factors affecting the company's activities. An analysis of the external and internal environment of the oil company identifies favorable and unfavorable factors. This has a direct impact on the implementation of the assigned tasks and the implementation of the strategy.

In general, among the numerous factors that impact the operations of an oil company, it is possible to identify common factors that are characteristic of the entire oil company. However, it is imperative to acknowledge that enhancing the efficiency of oil companies is imperative to guarantee its balanced growth in the future, encompassing its distinct business segments. The concept of sub-potentials should be taken into account in the practical development and implementation of development strategies for the territory, the oil and gas sector and particular large companies.

3.4. Methodology for Selecting Projects to Improve the Efficiency of Business Processes for the Development of an Oil Company

Ensuring the sustainability of the strategic development of companies and increasing the efficiency of their business processes is associated with a comprehensive assessment of projects accepted for implementation and financing. When selecting projects, their comprehensive assessment is required, taking into account various indicators, since often in practice it is necessary to select from projects that have different time and quality characteristics. Such a method, which provides an integrated approach to project selection, is the standard method. The reference point approach consists of determining an indicator characterizing the deviation (distance) from the optimal point (reference point) to specific values of the indicators of the projects being evaluated. Each project is considered as a point in n-dimensional space; point coordinates are assigned to the values of the indicators by which the comparison is made. Then, the concept of a standard is applied; this is the project for which all indicators have the best values among a given set of projects.

We selected three exploration and production projects from the national oil company PEMEX. From the Projects Mexico Hub platform that presents data on federal projects open to foreign investment, we selected three leading projects in the areas of exploration and production. The criteria for choosing them were the volume of investment and its potential to increase the amount of hydrocarbons in the economy.

We selected three farm-out projects. Farm-outs are associations between the public and private sectors that allow PEMEX to share financial, technological and geological risks with a private company. The purpose of selecting these projects is to compare onshore projects with deepwater projects. In Table 4 we present the key sustainability data of these projects from their public investment passports.

Table 4. PEMEX public–private associations open for investment in 2023–2024 [79–81].

	(1) Hydrocarbon Extraction in Tabasco in Association with PEMEX, Area 3 (Cárdenas—Mora).	**(2) Hydrocarbon Extraction in Tabasco in Association with PEMEX, Area 4 (Ogarrio).**	**(3) Exploration and Extraction of Hydrocarbons in Deep Waters of the Gulf of Mexico in Association with PEMEX, Area 1 (Trion).**
Estimated investment USD	1.241.967.997	922.900.253	430.731.290
Project Term	25 years	25 years	35 years
Type of oilfield	On land (Area: 156 km)	On land (Area: 168 km)	Deep water (Area: 1285 km)
Type of hydrocarbon extracted	Light oil and super light oil	Light oil and wet gas	Light oil and associated gas
Prospective resources	3P Reserves: 93.19 MMbpce	3P Reserves: 54 MMbpce	P90 Reserves: 181 MMbpce
Economic and social return of the project	0	2	0
Financial sustainability of assets	3	3	3
Detailed risk analysis	1	3	3
Clarity of cash flows and economic solvency	2	3	3
Effects on biodiversity in the area and native flora/faunas	0	1	3
Control and monitoring of contaminants	1	1	3

In this table, we can observe the public projects with private participation in light oil extraction. Light oil is more profitable for Mexico's strategy because it represents lower refining costs and existing fields are increasingly mature and have larger quantities of heavy oil. For this reason, it is necessary to develop new projects that compensate for the maturity of existing oilfields. However, these projects are located on relatively small reserves or in geologically difficult areas, as the table shows. Projects (1) and (2) are located onshore with limited reserves, but with a development duration of 25 years, and project (3) has prospective large reserves, but with a duration of 35 years. For this reason, it is necessary to balance which of the two alternatives is more efficient and sustainable.

The ecological assessment of these projects is still preliminary as shows the valuation in the table. The sustainability analysis of the projects is carried out by Banobras, the investment bank of the Mexican government, and defined by the Inter-American Development Bank and consists of classifying the availability of information on economic and environmental sustainability practices in an infrastructure project. These assessments are as follows: Tier 1 General or poorly detailed information (Identification), Tier 2 Detailed information, with defined procedures and resources (Mitigation). Only the last project in Tier 3 has a more defined ecological assessment in Tier 3.

For each project, the value of its rating score is determined by the formula:

$$K_j = \sqrt{\left(1 - X_{1j}\right)^2 + \left(1 - X_{2j}\right)^2 + \ldots + \left(1 - X_{nj}\right)^2}, \quad (1)$$

where X_1 represent the coordinates of the matrix points—the standardized indicators of the *j*-th company, which are determined by the ratio of the actual values of each indicator with the reference one according to the formula:

$$X_{ij} = \frac{a_{ij}}{\max a_{ij}}, \quad (2)$$

where $\max a_{ij}$ is the reference value of the indicator. A matrix is then compiled with standardized coefficients, calculated as the quotient of dividing each actual indicator by the reference one. We present this matrix in the results section. The lesser the value of this indicator, the more efficient the project. Therefore, we make the hypothesis that the most valuable projects in terms of reserve and ecological sub-potentials will continue to be efficient after this estimation. We selected projects with contrasting characteristics that are open for investment as of the 2023–2024 period, and the common element is the type of contract by which they are implemented.

4. Results

Extractive industries activities consume large quantities of resources. The proposed concept of sub-potentials allows us to substantiate that including the sustainability factor ultimately does not reduce, but rather increases the potential of the territory and the oil and gas sector. At the same time, benchmarks must be calculated to identify the threshold of transition from the sub-potential of functioning and development to the sub-potential of threat and containment.

To increase the efficiency of the strategic development of oil producing companies in Mexico, and ensure the socio-economic and organizational unity of the processes of their activities and the development of the Mexican economy as a whole, this study proposes to use the concept of sub-potentials [16].

The proposed conceptual approach contains four stages from top to bottom, presented in Figure 3. The first stage is to study the potential for exploitation and development of the territory from the point of view of the capabilities of large oil companies. The potential of a territory can be represented as a system of sub-potentials for functioning and development, which, in turn, include four sub-potentials: reproduction, defense, management and reserve. Emissions into the environment and pollution of the territory should be considered as sub-potentials of threat and containment that must be neutralized so that the territorial system can function and develop under normal conditions.

It is necessary to take into account that under certain conditions, sub-potentials of functioning and development can turn into sub-potentials of threat and containment and vice versa. An important task is to determine the specific facets of the transition, taking into account the peculiarities of the country's development. It should be emphasized that given the influence of oil companies on the development of the country's economy as a whole (both positive for the growth of state budget revenues and negative in the case of environmental pollution), the development of a company's strategy should be integrated into the territory's development strategy. In accordance with the structure of business processes presented in Figure 2, strategy development refers to the business processes of enterprise management and development.

At the second stage, the formation of a development strategy for oil producing companies is carried out, taking into account the analysis of the overall strategy of the environmental and economic development of Mexico. The strategy of oil enterprises should contribute to the achievement of comprehensive strategic goals of territorial development, reflected by the corresponding target indicators. The strategy is implemented on the basis of projects aimed at achieving strategic goals and indicators. Therefore, it is important to select the most effective projects, during which economic, environmental and other factors must be taken into account in a comprehensive manner.

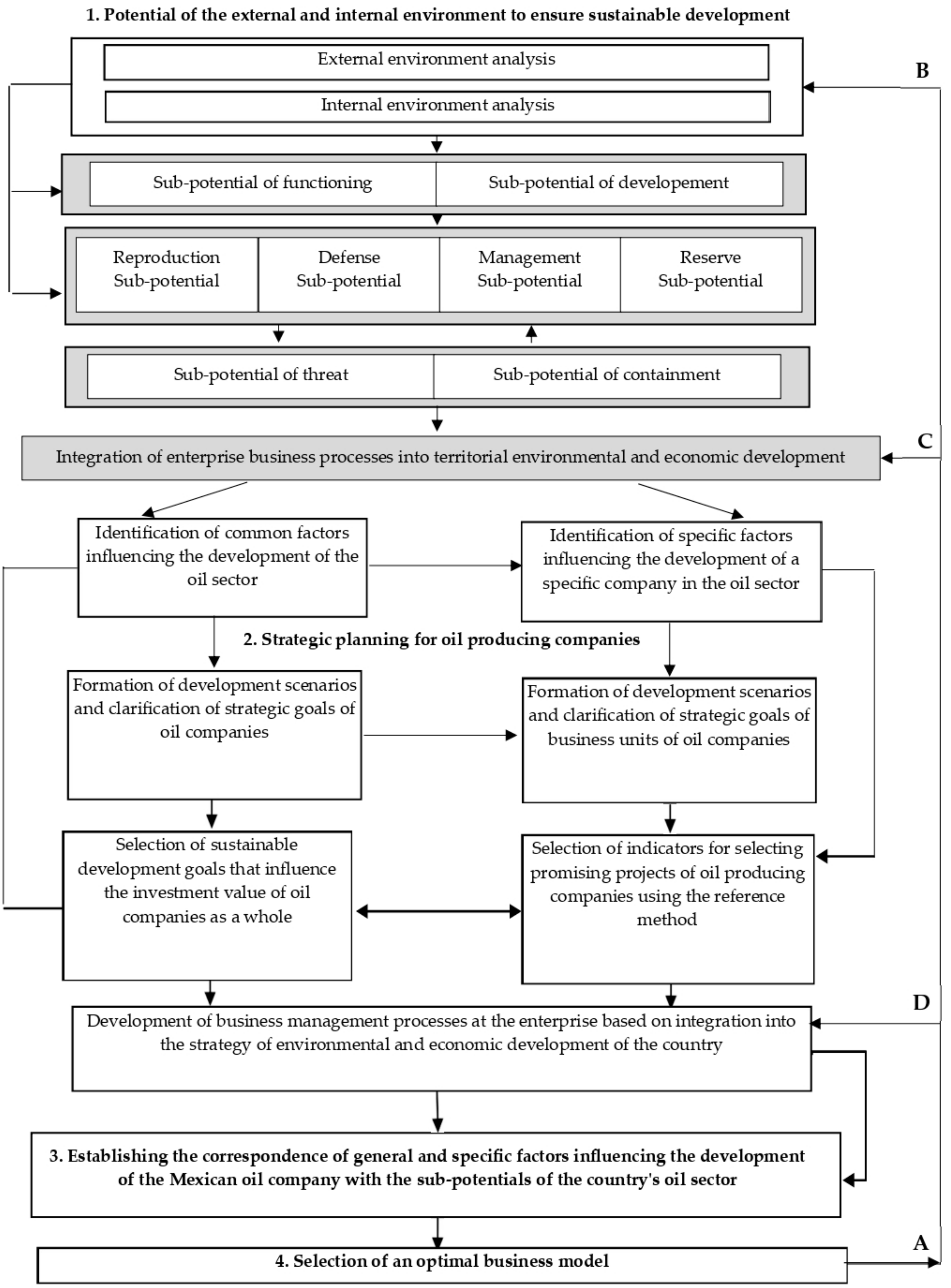

Figure 3. Diagram for the formation of a business model based on the concept of sub-potentials.

At the third stage, it is necessary to establish compliance with the development strategy of the oil producing company according to industry objectives and ensure an increase in the contribution of oil companies to the development of the sector as a whole. Considering these processes, at the fourth stage, the optimal business model is selected.

It should be noted that in in the implementation process, factors of both the internal and external environment of the enterprise may change. Accordingly, if necessary, the strategy can be adjusted using an iterative communication chain AB within the framework of the presented methodology. If necessary, adjustments are made to the AC and AD circuits.

The methodology used in this article allows for increased project efficiency due to the properties of synergy and emergence. The property of emergence is associated with the contribution of the industry to the environmental and economic development of the country. The multiplicative property inherent in large systems leads to a significant increase in negative consequences when threats arise. This property also applies to positive effects; however, in such cases its influence is much less pronounced. Considering the tendency of multiplicativity to enhance unfavorable impacts, the concept of sub-potentials acquires special significance. According to the approach developed in this article, sub-potentials delineate the boundaries between positive and negative outcomes.

In this section, we present a point method evaluation of the ecological component of the oil industry to study the types of pollutants based on those from Table 3. The objective is to determine the characteristics for the sub-potentials of threat and containment, despite indicators of pollutants which were not included in the Sectoral Plan.

Next, we implement the matrixes described in the case study section to estimate the reference point approach for the three exploration and production projects. This gave us the selection of an optimal project that combines sustainability and efficiency criteria.

Finally, we determine the critical values for the efficiency thresholds for the reproduction, management and defense sub-potentials though an analysis of the production and quality of offshore oil in Mexico and we apply the ecological indicators on the territory of the selected project.

4.1. Assessing the Impact of Oil Company Projects on the Environmental Situation in Mexico

We analyzed the variables of environmental sustainability that the literature from oil companies presented and did not present in the Energy Sectoral Plan, namely spills and emissions. To conduct the point method evaluation, we examined each criteria group by pollutant, weighting its relevance in relation to the PEMEX budget for Operation and Maintenance of Ecological Infrastructure, as presented in Table 3 in the Materials and Methods section. The aim of this calculation was to complement the evaluation completed in the Sectoral Plan, and establish how important are oil spills and emissions from the oil industry for the Energy Sectoral Plan objectives. Therefore, we can know how important each activity is to the company and generate a sustainability evaluation. We present the following in Table 5, normalizing the values of these to two ecological effects, pondered by budget, to identify their relevance and construct the point method analysis in Table 6.

The normalized trends presented in the table illustrate a rising problem of spills and emissions [54]. The highest values for leaks and spills variables occurred in the 2020–2022 period, while the peak for emissions occurred in 2020. To assign a letter designation to an environmental aspect, a point rating system is used based on the Energy Sectoral Plan and its relation to the previous normalized values of the ecological indicators. All environmental aspects are assessed according to four groups of criteria: (1) scale of impact in the Sectoral Plan; (2) characteristics of impact controllability stated in the plan; (3) costs of eliminating the consequences of the impact as related to the federal budget for the oil sector; (4) degree of urgency to reduce impact in the Plan. Each group includes five evaluation parameters, for each aspect of which a score is assigned from 1 to 3. The scores obtained for each evaluation parameter are summed up within one group of criteria. We conduct this analysis in Table 6 for the Oil Leaks and Spills and Greenhouse Gas Emissions dimensions.

Table 5. Normalized values of the ecological indicators weighted by the budget for Operation and Maintenance of Ecological Infrastructure.

Year	Leaks and Spills. Events	Leaks and Spills. Released Volume (b)	CO_2 Emissions (MMt)	SOx Emissions (Mt)
2010	0.01	0.64	0.06	0.04
2011	0.00	0.01	0.02	0.01
2012	0.02	0.00	0.01	0.00
2013	0.00	0.49	0.00	0.00
2014	0.01	0.01	0.05	0.03
2015	0.02	0.03	0.08	0.05
2016	0.04	0.04	0.26	0.20
2017	0.05	0.02	0.14	0.12
2018	0.56	0.12	0.35	0.29
2019	0.81	0.19	0.46	0.50
2020	1.00	0.08	1.00	1.00
2021	0.85	0.12	0.71	0.76
2022	0.75	1.00	0.60	0.57

Table 6. Point method evaluation of leaks and spills and greenhouse emissions.

	Description of Criterion	Oil Leaks and Spills	Greenhouse Gases Emissions
Criteria group 1: Impact assessment		B	A
1. Scale of the impact on the environment and public health	local (within the enterprise territory)		
	local (within the territory of the administrative district)	2	
	regional (within the boundaries of the administrative region)		3
2. Gross quantities of pollutants	minor (up to 10% of the total volume)	1	
	average (from 10 to 50%)		
	significant (more than 50%)		3
3. Degree of danger of pollutants (by the most dangerous substance)	low: 4th, 5th grade		
	secondary: 3rd grade		2
	high: 1st, 2nd class	3	
4. Share of payments in the total structure of payments for negative impacts on environmental protection	No		
	up to 50%	2	2
	more than 50%		
5. Degree of load on the territory	low (up to 10% of the territory is occupied by technological equipment)	1	
	average (up to 50%)		2
	more than 50%		

Table 6. *Cont.*

	Description of Criterion	Oil Leaks and Spills	Greenhouse Gases Emissions
Group of criteria 2: Characteristics of impact controllability		B	B
1. Availability of permits	Availability		1
	absence	2	
	availability of documents is not required by law		
2. The level of deviation of the impact of an aspect on the ecosystem from the standard	complies with standards	1	
	exceeds the standard		2
3. Compliance with legal requirements	corresponds	1	1
	does not match		
4. Possibility of visual detection of impact	discovered upon examination		
	detected in a single analysis	2	
	discovered during special studies		3
5. Duration of exposure	up to 24 h		
	from 24 h to 7 days		
	more than 7 days	3	3
Group of criteria 3: Costs of reducing (eliminating) impacts		A	A
1. Compensation for damage to the operating system (payments)	fines were not paid		
	payments in the past (more than a year ago)		
	systematic payments	3	3
2. Costs of conducting impact studies	no studies have been conducted		
	studies have been conducted in the past		
	research is carried out systematically	3	3
3. Necessity of costs for implementation of BAT to reduce impact	no costs required		
	costs are possible		2
	immediate costs required	3	
4. Costs of compensation for harm to health	none		
	were paid previously		2
	are paid regularly	3	
5. Costs of carrying out work to restore the ecosystem	not required		
	were paid previously		2
	are paid systematically	3	
Criteria group 4: Level of urgency to reduce impact		A	B
1. Impact on the background state of the ecosystem	does not affect the background state		
	has little effect		2
	significantly influences	3	
2. Complaints from interested parties (public)	none		
	systematic		2
	exposure threatens the health and life of the population	3	

Table 6. *Cont.*

	Description of Criterion	Oil Leaks and Spills	Greenhouse Gases Emissions
3. Comments from regulatory authorities	none		
	exhibited no more than 2 times a year	2	2
	aspect is a constant object of control		
4. Staff comments and requirements	were not presented		1
	were presented periodically		
	presented regularly (more than 2 times a year)	3	
5. Wear of technological equipment from the established operational service life	up to 50%		
	from 50 to 100%	2	2
	more than 100%		

A group of criteria is assigned the letter code "C" if the sum of points for the group of criteria is from 5 to 7.

A group of criteria is assigned the letter code "B" if the sum of points for the group of criteria is from 8 to 11 points.

A group of criteria is assigned the letter code "A" if the sum of points for the group of criteria is from 12 to 15 points.

The integral importance of an aspect is assessed using a repeating letter code, as shown in Table 7.

Table 7. PEMEX ecological aspects of leaks and spills and greenhouse gases emissions.

Ecological Aspect	Relevance of Each Aspect by Criteria Group			
	Group 1	**Group 2**	**Group 3**	**Group 4**
Oil Leaks and Spills	B	B	A	A
Greenhouse Gases Emissions	A	B	A	B

For the Criteria group 1: Impact assessment, greenhouse gases have a better assessment value than oil leaks; this can be explained because of the present priorities of country reporting. Group of criteria 2: Characteristics of impact controllability have a B reporting quality for the two indicators. Group of criteria 3: Costs of reducing (eliminating) impacts represent high values of reporting, as there is budget allocated to these indicators. Criteria group 4: Level of urgency to reduce impact represents higher value for oil spills as their impact is more urgent and visible than emissions.

These results illustrate that although greenhouse gas emissions are measured in detail, they do not represent a priority in the short term, while spills represent a priority in the short term in terms of remediation, but not in terms of prevention. In the following section we address the integration of sustainable parameters to project selection in Mexico.

4.2. Increasing the Efficiency of Business Development Processes Based on an Integrated Approach to Project Selection

The selection of projects requires a comprehensive consideration of economic and environmental factors. To contribute to the literature of sustainable management of oil resources in Mexico, we analyze at a project level the use of sustainable indicators. To build upon the existing literature for the Mexican oil sector we go beyond the diagnosis that the country's conventional and current resources must be explored further. Rather, we look at deepwater projects and the possibility of producing light oil on offshore fields. We propose to provide an integrated approach when selecting projects based on the benchmark method. The next matrix evaluates the effectiveness of projects using this method using the formulas discussed in Section 3.2. First, we conduct a study of deviations of projects from the maximum value of their indicators, according to Formula (2) form the previous section.

Then, we calculate the specific values of the standard using Formula (1). In Table 8, a new matrix is presented where the square of the sum is established for each indicator and project. Projects are ranked in descending order of rating score. The project with the minimum rating value is the most effective, according to the chosen sustainability indicators.

Table 8. Reference results for PEMEX public–private associations.

	(1)	**(2)**	**(3)**
Estimated investment USD	0.00	0.07	0.43
Project Term	0.08	0.08	0.00
Type of oilfield	0.77	0.76	0.00
Type of hydrocarbon extracted	0.25	0.00	0.00
Prospective resources	0.24	0.49	0.00
Economic and social return of the project	1.00	0.00	1.00
Financial sustainability of assets	0.00	0.00	0.00
Detailed risk analysis	0.44	0.00	0.00
Clarity of cash flows and economic solvency	0.11	0.00	0.00
Effects on biodiversity in the area and native flora/faunas	1.00	0.44	0.00
Control and monitoring of contaminants	0.44	0.44	0.00
K_j	**2.08**	**1.51**	**1.19**

For the indicator K_j, the lower the value, the more effective the project will be for national objectives. We observe that the project "Exploration and extraction of hydrocarbons in deep waters of the Gulf of Mexico in association with PEMEX (farm-out), area 1 (Trion)" corresponds with the recommendations of the literature for Mexico, in which deepwater projects should be privileged despite their complexity, since they have more potential and better-quality resources. Next, we describe the project.

The Trion field, located in the Deepwater Gulf of Mexico Basin, was discovered by PEMEX in 2012. In 2017, as result of the bid of the public–private association project, Woodside Energy signed an agreement with PEMEX and the Mexican government to become the developer of the field with a 60–40% partnership between the private company and PEMEX. Subsequent appraisal efforts have estimated approximately 471 million barrels of oil and 425 billion standard cubic feet of gas as recoverable reserves. Development planning activities have been underway since 2020.

The investment program presented by the private company to the National Hydrocarbons Commission of Mexico estimates a total cost of 10,433.95 million USD, for the period from 2023 to 2052. The expense assigned to the Safety, Health and Environment category is USD 30.35 md., that is, 0.3% of the total expense and 0.5% of project development expenses. The technology for this area includes digitalization tools and systems that improve production efficiency and reduce security risks.

4.3. Efficient Thresholds for the Reproduction, Management and Defense Sub-Potentials

In this section, we determine the thresholds for the efficient operation of the sub-potentials, and their transition values to the threat and containment sub-potential. In the first place we concentrate on the sub-potential of reproduction through the capacity of the country to continue the production of offshore oil and determine where does it starts to debilitate. In second place, we concentrate on the reserve sub-potential to determine the efficient threshold of sustainable production of quality oil, that is super light and light oil that is easier to refine. Lastly, we determine the efficient threshold of the defense sub-potential using the environmental data applied hypothetically in the territory of the selected project to determine when it could transit to the sub-potential of threat and containment.

As a result of the calculation of the index presented in the previous algorithms, the planning priority for the development of an offshore project in deep waters for the company PEMEX and ensuring its business processes of management and development was established. According to the proposed methodological approach, the implementation of this project increases the potential for the functioning and development of the territory as a whole.

In Mexico, there is a disparity in the quality of oil produced in land and in sea [82]. In sea, the shallow-water oilfields have reached a state of maturity, while deepwater fields have been explored, revealing light oil resources, but are costly to exploit. In this section, we establish the problem of why our project choice of deepwater exploration is relevant within Mexico's oil mix. For this we try to define the transition value in which quality oil passes from the reproduction sub-potential to the containment sub-potential. That is the transition point in which the production of light oil falls to an unsustainable scenario. Historically, shallow-water deposits have been the most productive. However, the maturity of these fields has meant that most of the super light crude oil is extracted on land, while more heavy oil is extracted in water.

Though offshore oil represents the majority of the resources extracted in Mexico, the debilitating production from offshore fields represents the main point of debate of the Mexican oil industry. It is necessary to identify the threshold that determines not only the downward trend but also an unsustainable level of production. We normalized the values for offshore oil production in Table 9.

Table 9. Normalized values for the growth rate of the production of hydrocarbons in shallow waters [83].

Year	2017	2018	2019	2020	2021	2022	2023	2024
Production of hydrocarbons by origin	0.00	0.14	0.37	0.68	0.96	1.00	0.95	0.32

The normalized values allow us to identify the median of the distribution and establish that, after the value 0.60 in the distribution, there is a non-linear decrease in production; this is the transition point in which the sub-potential of reproduction passes to the sub-potential of threat and containment. Represented further, in Table 10, a decrease production in offshore fields under 0.2 points represents a score of 0, if it reaches 0.2 points corresponds to 5 points; from 0.6 and more—10 points.

Table 10. Normalized values for the growth rate of the production of superlight and light hydrocarbons in shallow waters [83].

Year	2017	2018	2019	2020	2021	2022	2023	2024
Production of superlight and light hydrocarbons in shallow waters	0.62	0.58	0.53	0.55	1	0.67	0.56	0.00

Next, we observe the production of light and super light oil. Although most of the production comes from offshore fields, the quality of the crude oil extracted from them has decreased. The percentage of heavy crude oil is greater than light crude oil in marine fields. The explanation lies in the fact that most of these deposits are in a state of maturity with wells opened more than 15 years ago. Consequently, most of the best-quality crude oil after 2020 is extracted not from onshore fields, but these smaller fields with lesser yields. To know the value in which the sub-potential of reproduction transitions to a containment sub-potential, we calculated the growth rate of light-oil production in land and offshore fields in Mexico.

The year 2021 represented a change in the historical trade of light oil produced in Mexico. The production peaked in this year, but also represented the beginning of a downward trend. Production from offshore fields decreased, and there was a higher proportion of Mexico's light oil while production of light oil in onshore fields stayed more or less the same. We present the normalized values in Table 10.

We can establish the transition threshold for the production of light oil from offshore fields between the maximum and minimum at 0.6 percentage points of the distribution. A decreased production in offshore fields under 0.2 points represents a score of 0; if it reaches 0.2 points corresponds to 5 points; from 0.6 and more—10 points. When the production reduces under this vale there is a risk to transition to a containment sub-potential, which represents that there are not enough new light oil projects to replace the mature oilfields in the Gulf of Mexico. Light oil is relevant as it is less costly, and more productive to refine in order to produce fuel and petrochemicals. The resources of deepwater fields in Mexico contain light oil, as evaluated in the Results section; therefore, is relevant to develop this type of project to address this gap in high-quality resources.

Within the framework of the concept of sub-potentials, the development of this project within the Mexican oil industry ensures an increase in the reserve sub-potential and, accordingly, the overall potential for operation and development. These findings match with the recommendations of the literature.

Project implementation is one of the final business development processes. Large oil industry projects have a significant impact on the environmental situation in the region. At the same time, it is necessary to control that the transition of development sub-potentials into the sub-potential of threat and containment does not occur. To accomplish this, it is necessary to determine the boundaries of such transitions based on indicators in the specific conditions of the country. To calculate the transition point from the defense sub-potential to the sub-potentials of threat and containment, we propose to measure the index of anthropogenic pressure over the territory, linking the potential oil spills to the area of the oilfield. These indexes have been used to study ecological impacts of industrial activities [84]. This index will allow us to know the limits of potential oil spilling in the territory. The coefficient of anthropogenic pressure is calculated on the basis of oil spills per territory with this formula:

$$K_j^a = \frac{E_j/S_j}{\frac{1}{n}\sum_{j=1}^{n} E_j/S_j} \tag{3}$$

where E_j is the yearly oil spills in the region$_j$, S is the area of the oilfield in kilometers, n is the number of years. For the period from 2010 to 2022, we used the reporting of oil spills of PEMEX and the territory of the selected oilfield. We are interested in separating the trends of constant spilling from years in which accidents occurred in order to find a key value for the constant activities. For this reason, we select the median of this index.

Using this indicator, we normalize a scale of points to create a rating. When evaluating the readiness of a particular country to improve its production factors in the oil and gas sector, we should take the sustainability components into account; the results are shown in Figure A9 of Appendix A. The anthropogenic pressure coefficient reached a medium value of 0.2. We have to take in account the years in which accidents happened that resulted in big oil spills that broke the trend of "normal spills". These are 2010, 2013 and 2022.

Within the framework of a business-process approach to improve the effective planning of projects in the oil sector, we propose to include the coefficient of anthropogenic pressure to the system of environmental performance indicators, and then, to derive an integral indicator for assessing efficiency, a scoring system is proposed. The variation between the maximum and minimum of the distribution is 0.6 percentage points. If the indicator increases, then 0 points are assigned. A decrease in the anthropogenic load coefficient to 0.2 corresponds to 5 points; from 0.2 and more—10 points.

Then, we calculate the management sub-potential, using the EBITDA from the company PEMEX as the key management indicator for the oil industry in the Sectoral Energy Plan, using the deflated values in thousands of millions of dollars.

We see a recuperation of the EBITDA after the pandemic. It is an indicator heavily correlated to oil prices, which explains the better values for the 2021–2023 period. However, the pandemic was a shock that also reverted the downward trend that started in 2018. We normalize its values in Table 11.

Table 11. Normalized values for the EBITDA of PEMEX in MMUSD [78].

Year	2017	2018	2019	2020	2021	2022	2023
PEMEX EBITDA in MMUSD	0.76	0.76	0.49	0	1	0.72	0.73

We can establish the transition threshold for the production of light oil from offshore fields between the maximum and minimum at 0.7 percentage points of the distribution. A decreased production in offshore fields under 0.4 points represents a score of 0; if it reaches 0.4 points, it corresponds to 5 points; from 0.7 and more—10 points.

Expanding on our previous work [16], in Table 12 we present a scoring system based on the previous normalized threshold for the four sub-potentials with specific values for Mexico.

Table 12. Indicators to ensure the stability of sub-potentials for functioning and development for the oil industry in Mexico.

<table>
<tr><th>Name of the Sub-Potential</th><th>Name of Indicators</th><th>Criteria Weight</th><th>Points</th><th>Characteristics of Indicators</th><th>Recommended Values of Indicators in Points</th></tr>
<tr><td rowspan="3">Reproduction</td><td rowspan="3">Yearly production of hydrocarbons from offshore fields</td><td rowspan="3">0.25</td><td>10</td><td>Indicator increase of 0.6 or more</td><td rowspan="3">y ≥ 5</td></tr>
<tr><td>5</td><td>Change from 0 to 0.6</td></tr>
<tr><td>0</td><td>Indicator increases</td></tr>
<tr><td rowspan="3">Reserve</td><td rowspan="3">Yearly production of superlight and light hydrocarbons in shallow waters from offshore fields</td><td rowspan="3">0.25</td><td>10</td><td>Indicator increase of 0.6 or more</td><td rowspan="3">y ≥ 5</td></tr>
<tr><td>5</td><td>Change from 0 to 0.6</td></tr>
<tr><td>0</td><td>Indicator increases</td></tr>
<tr><td rowspan="3">Defense</td><td rowspan="3">Potential environmental impact of oil spills in the territory of a project (coefficient of anthropogenic pressure)</td><td rowspan="3">0.25</td><td>10</td><td>Indicator increase of 0.2 or more</td><td rowspan="3">y ≥ 5</td></tr>
<tr><td>5</td><td>Change from 0 to 0.2</td></tr>
<tr><td>0</td><td>Indicator increases</td></tr>
<tr><td rowspan="3">Management</td><td rowspan="3">PEMEX EBITDA in MMUSD</td><td rowspan="3">0.25</td><td>10</td><td>Indicator increase of 0.7 or more</td><td rowspan="3">y ≥ 5</td></tr>
<tr><td>5</td><td>Change from 0 to 0.7</td></tr>
<tr><td>0</td><td>Indicator increases</td></tr>
</table>

Exploration and production projects should consider values of 5 or higher in this calculation. Limitations of our calculation of the anthropogenic pressure index are that results are calculated for any offshore project. We identify the specific values for the case of Mexico under which the industry cannot operate in an efficient manner and transitions to the threat and containment sub-potentials. Further analysis should incorporate a ponderation to differentiate deepwater from shallow-water projects.

5. Discussion

To ensure the sustainable development of oil producing enterprises, an integrated approach was used, which is implemented through an integrated system of indicators when selecting projects. The authors' approach takes into account not only economic components, but also environmental and social indicators. It should be emphasized that the methodology is relevant, since the results of the analysis of Mexico's strategic documents on the development of the oil industry show that the goals set are not always achieved. This requires additional developments in the field of these techniques and methodology.

5.1. Ensuring the Sustainability of Business Development Processes Based on the Concept of Sub-Potentials

The contribution of this study within the literature is to provide a conclusion based on project evaluation. The studied projects give us an insight into the priorities of sustainability in the extractive industries. In Mexico, sustainability priorities align with the economic and social side, giving priority to the reserve and production potential, but the ecological aspect has a second place in project planning objectives. We complement the literature based on time panels analyzing at a project level variables as emissions, spills and the sustainability of reserves and economic performance of the company.

The use of the concept of sub-potentials and the business model presented in Section 1 of Figure 3 makes it possible to consider the environmental component not only as a costly part, but also as part of business processes that increase the sub-potentials of the operation and development of an oil producing enterprise. This will increase the enterprise's interest in taking into account the environmental component as presented in the second part of Figure 3 [85]. In addition, this approach allows the integration of the environmental component into various business processes of an oil producing enterprise. That is, it is necessary to pursue not an isolated environmental policy, but a unified environmental and economic policy. This will allow the environmental factor to be taken into account as effectively as possible in the design and current activities of the enterprise.

Increasing the sub-potential for reproduction is ensured by simultaneously solving the problems of current functioning and future development based on an integrated consideration of economic and environmental factors. The selected economic indicators, oil spills and greenhouse gas emissions, are a manifestation of the multiplicative property; effects (especially negative ones) are amplified in a large system [17]. Using the example of oil spills we implemented in the selected project, we can observe negative consequences for the territory as a whole.

In this regard, it is necessary to assess the impact of projects on the sub-potential for defense in the territory, which is the measure of ecological sustainability. To accomplish this, it is necessary to determine the critical values of indicators that can show the line of transition from the sub-potential of functioning and development to the sub-potential of threat and deterrence. For this, we calculate an index of anthropogenic pressure to propose the limits in which this transition happens.

Although the objective of analyzing a single company as a corporate entity with subsidiaries was to achieve greater efficiency for PEMEX, the overall strategy of income absorption and erosion of each segment of the supply chain debilitated the company. Some recommendations aim to reduce the natural resources rent that the company generates. In the case of Mexico, this consists of freeing PEMEX from the fiscal burden of paying the tax on profits, as well as reducing surcharges on hydrocarbon extraction and exploitation. The reduction of PEMEX's tax payments to the federal government would be so that this company can reinvest its profits in hydrocarbon production and refining [59].

The 2014 energy reform changed the priorities of the energy sector at two levels of analysis: The first is related to technological change. The second is the energy transition and migration of institutional mechanisms. The government is not adequately equipped to make decisions on energy sector projects with sufficient economic potential [86].

Greenhouse gas taxes were incorporated in the Mexican reform, but they target end consumers and exceptions for some users were introduced in 2022 [74]. To address the types of emissions presented here (spills and greenhouse gas emissions), there is a need to present a new policy method based on the theory of externalities at the production level.

The validity and correctness of the conclusions obtained is confirmed, among other things, by the fact that currently the most effective in the development of innovative processes are network models that involve close interactions between businesses, the scientific sector and the state. This article does not discuss network models, double helix and triple helix concepts in detail, but the authors' findings for oil production and Mexican development are consistent with these modern theoretical approaches, which confirms the validity of the conclusions.

5.2. Policy Implications

A circular economy business model orientation in PEMEX towards deepwater projects is needed to increase the sub-potentials of reproduction and defense. The literature describes the problem of going beyond conventional resources in Mexico; these resources are in a state of maturity and are not as productive as in the past, since they generate less and less light oil. For this reason, it is necessary to understand the development of projects in deep waters, where greater production of this type of oil is predicted. However, spills and greenhouse gas emissions have been increasing at PEMEX and new developments must include better ecological planning. Current national planning does not include specific goals for the oil sector. For this reason, it is necessary to propose the indicators that will be relevant for the new planning exercise that is carried out every five years.

Further steps in this research consist in linking the specifics of financial analysis to the conclusion of this article. The government priority has not focused on deepwater extraction because it is perceived as expensive and the state company PEMEX suffers from a long-term debt. It is possible to analyze the new resources that were allocated to the company during the last six years and study the company focus on short-term exploration and production projects. If realized, long-term revenues may compensate for short-term spending on these projects. Also, diversification of the business model within oil companies is a path Mexico has not explored [42].

Some policy suggestions encompass the advocacy for green finance, the implementation of an effective emission taxation framework, provision of incentives for eco-friendly research and the establishment of a local network for green innovation among oil and gas enterprises, aiming to nurture sustainable practices [28]. Yearly, PEMEX makes an investors' presentation and searches for more funding; the company can incorporate more sustainable goals in its investment objectives.

Also, countries should initiate investments in research and development in order to achieve sustainable technological innovation, because it contributes significantly to lowering the ecological footprint [29].

6. Conclusions

The conclusions link the results to the problem formulated in the introduction in the following manner:

- the identified factors of the functioning of the Mexican oil industry in the conditions of modern and limitations of the industry and the region determine the need to develop a unified environmental and economic strategy for oil producing enterprises to ensure their sustainable development;
- a methodological approach to formulate a strategy for the development of oil producing enterprises in Mexico should include the formation of a circular economy business model and its integration into the development strategy of the oil industry based on the concept of sub-potentials, including the potentials of functioning and development, as well as threats and containment;

- the assessment of the Mexican oil industry projects should be carried out on the basis of a comprehensive methodology, taking into account not only economic, but also environmental and other factors;
- the selection of projects and their implementation must be carried out considering the values of indicators that determine the transition of sub-potentials of functioning and development into sub-potentials of threat and deterrence;
- the values of indicators for the transition of sub-potentials of functioning and development into sub-potentials of threat and deterrence for Mexico were established;
- a comprehensive consideration of sustainability factors, including environmental ones, does not lead to a decrease in the opportunities for economic development, but to an increase in the potential for the functioning and development of the territory and oil companies.

The gap between sustainable development goals and the implementation of oil projects exists because business processes to select oil projects focus on the short-term relation between production and budget. That means that projects in PEMEX do not prioritize enough ecology and the quality of oil in decision-making. Rather, they focus on the short-term relation between production and budget.

The planning priority for the development of an offshore project in deep waters for the company PEMEX and ensuring its business processes of management and development was established. The proposed methodology for this project enhances the potential for the functioning and development of the entire territory. Conclusively, this offshore project, when developed within the Mexican oil industry, boosts the reserve sub-potential and overall potential for operation and development.

The incorporation of the social component is a limiting factor in the application of a business model approach. Relevant stakeholders for national oil companies include the societies of the countries where the company operates, the local inhabitants and ecosystems, as well as the investors. Societies demand that the resources of the subsoil be returned to them in the form of subsidies. The integration of citizens, organizations and academia as voices in decision-making processes alongside fossil fuel corporations should be integrated. Limitations of this study are associated with the availability of part of the data for the Strategic Plan for the Mexican Energy Industry, available until 2022.

The proposed concept of sub-potentials allows us to consider the business processes of an enterprise in the interaction of functioning and development. In order to maintain the functioning of the company at a sustainable level, it is necessary to invest in effective projects at the present time. At the same time, the implementation of investment projects ensures increased efficiency of business development processes. When implementing insufficiently effective projects or with a lack of consideration for sustainability factors, including environmental ones, the sub-potentials of functioning and development can turn into sub-potentials of threat and deterrence. With effective management of the strategic development of oil companies, a reverse transition is carried out that can increase the positive sub-potentials for functioning and development.

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Data Availability Statement: The data used in this study are publicly available in the data from public sources by the company PEMEX and Mexico's Secretariat of Energy and Secretariat of Finance and Public Credit and the federal budget of Mexico as stated in the references. All the used data are presented in the tables within the article.

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

Appendix A

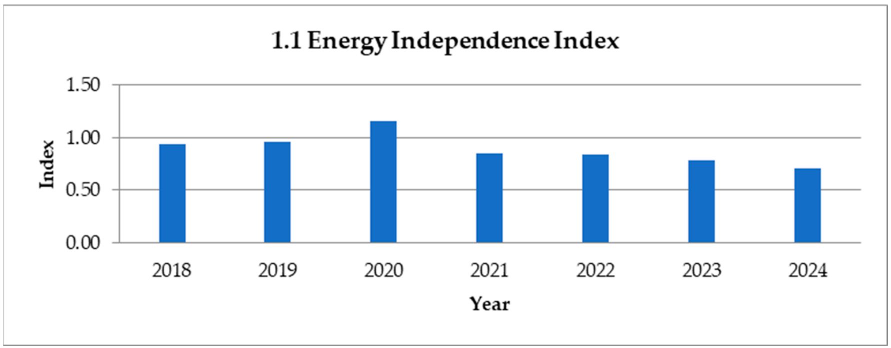

Figure A1. Percentage of achievement of goal 1 program indicators: 1.1 Energy Independence Index.

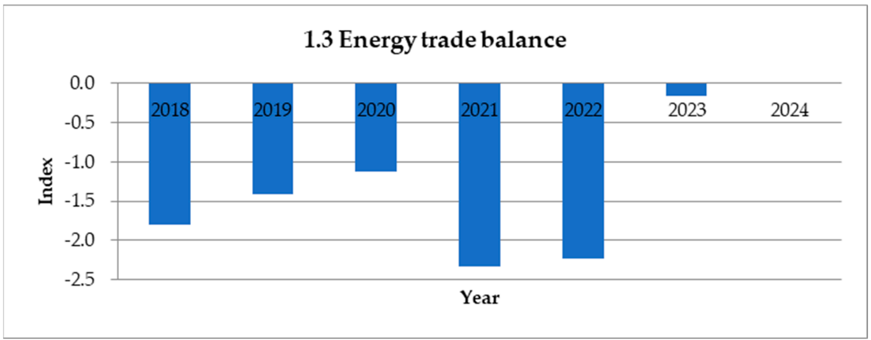

Figure A2. Percentage of achievement of goal 1 program indicators: 1.3 Energy trade balance.

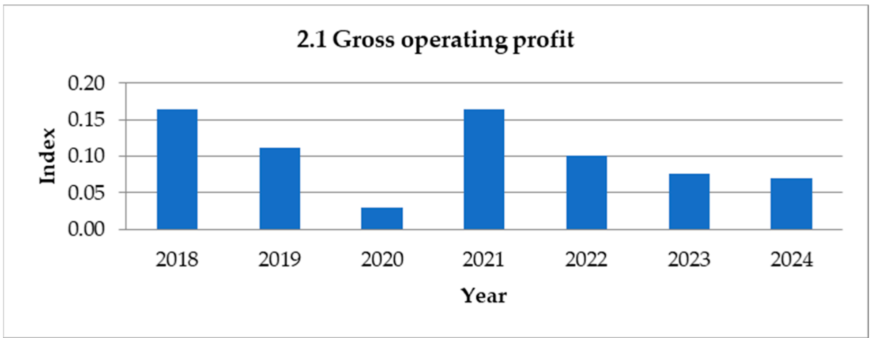

Figure A3. Percentage of achievement of goal 2 program indicators: 2.1 Gross operating profit.

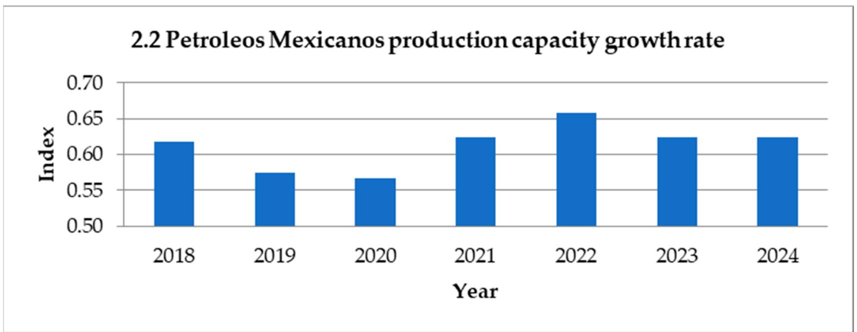

Figure A4. Percentage of achievement of goal 2 program indicators: 2.2 Petroleos Mexicanos production capacity growth rate.

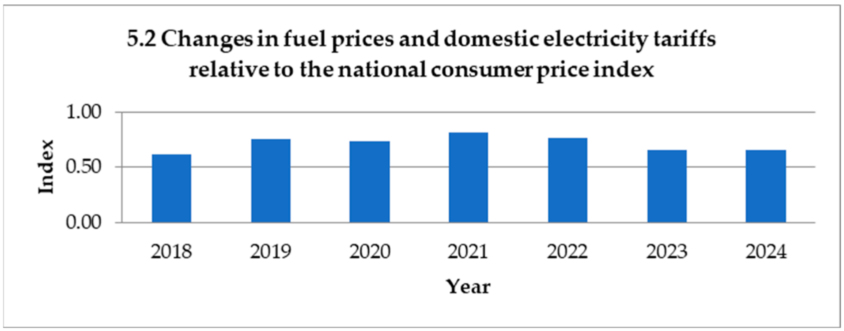

Figure A5. Percentage of achievement of goal 5 program indicators: 5.2 Changes in fuel prices and domestic electricity tariffs relative to the national consumer price index.

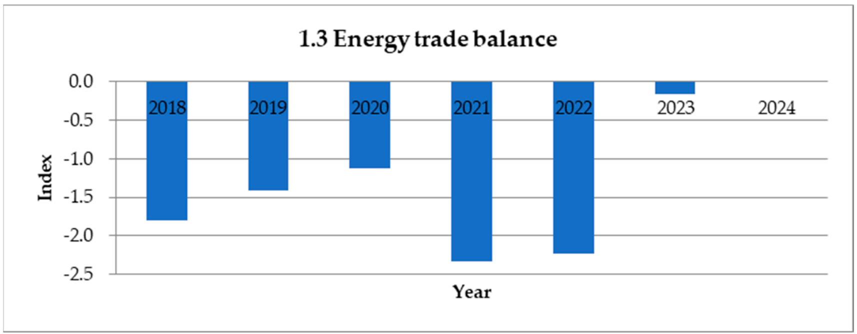

Figure A6. Percentage of achievement of goal 5 program indicators: 5.3 Differences in the scale of energy transport infrastructure.

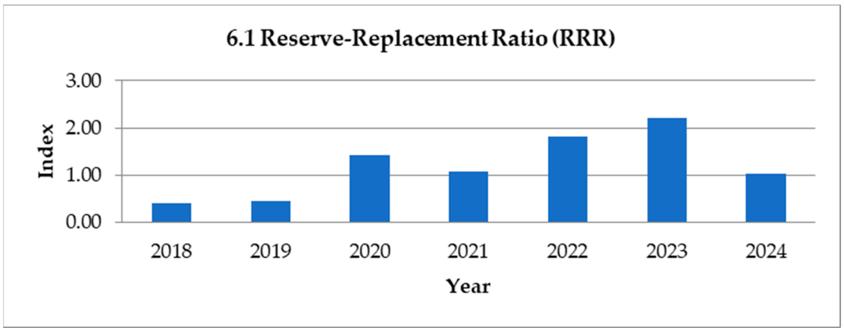

Figure A7. Percentage of achievement of goal 6 program indicators: 6.1 Reserve–Replacement Ratio (RRR).

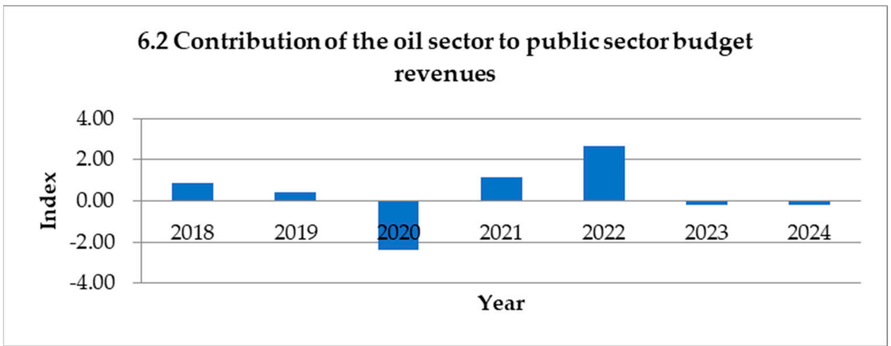

Figure A8. Percentage of achievement of goal 6 program indicators: 6.2 Contribution of the oil sector to public sector budget revenues.

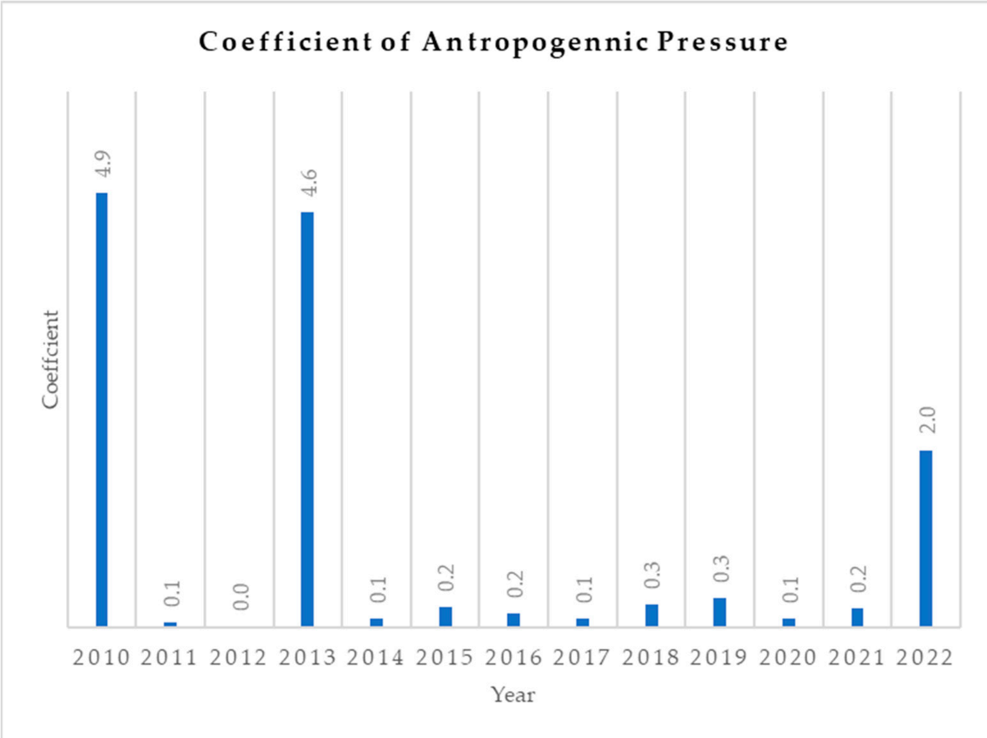

Figure A9. Coefficients of anthropogenic pressure for the project "Exploration and extraction of hydrocarbons in deep waters of the Gulf of Mexico in association with PEMEX, area 1 (Trion)".

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