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Enhancing Sustainability in Belize's Ecotourism Sector: A Fuzzy Delphi and Fuzzy DEMATEL Investigation of Key Indicators

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Abstract: Sustainable ecotourism has become a strategy to balance tourism growth with environmental and sociocultural considerations. This study aims to propose an integrated approach of the Delphi technique and the decision-making trial and evaluation laboratory (DEMATEL) based on fuzzy set theory to investigate sustainable ecotourism indicators in Belize. The study covers six dimensions: environmental, social, cultural, economic, political, and intrinsic. Firstly, the Fuzzy Delphi technique constructs a comprehensive set of indicators with expert consensus, resulting in 51 relevant and representative indicators out of the initial 63. Secondly, the Fuzzy DEMATEL approach is then applied to analyze the interdependencies among indicators and identify their causal relationships, providing insights into the complex dynamics of sustainable ecotourism in Belize. The results provide a structured decision-making framework to prioritize actions, allocate resources effectively, and promote sustainable practices in the ecotourism sector. Therefore, these findings enhance the understanding of indicator interconnections across dimensions, enabling informed decision making for policymakers, industry practitioners, and researchers. Policymakers can develop policies and regulations that foster sustainable practices, while industry practitioners can enhance visitor experiences, engage with local communities, and ensure the industry's long-term viability. Researchers can further investigate specific dimensions and indicators to advance the knowledge and implementation of sustainable ecotourism. Finally, this investigation supports the goal of achieving a harmonious and sustainable balance between tourism development and environmental preservation in Belize. By safeguarding the natural and cultural heritage of the region, sustainable ecotourism can benefit present and future generations.

Keywords: Belize; ecotourism; sustainable; MCDM; fuzzy set theory; Delphi; DEMATEL

MSC: 97M30; 91B02; 62P05; 91B84

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1. Introduction

Tourism is a rapidly expanding global sector that has significant implications for the environment, economy, and society [1]. In response, ecotourism has emerged as a sustainable tourism model that promotes responsible travel, environmentally friendly practices, and economic benefits for local communities [2–4]. Belize, a nation in Central America, has prioritized ecotourism to enhance environmental protection efforts and generate income for its citizens. The country boasts a diverse cultural and natural heritage, including the Belize Barrier Reef, the second-largest coral reef system globally, and numerous protected areas such as national parks, wildlife reserves, and marine reserves. Visitors worldwide come to Belize to experience its unique biodiversity and cultural heritage [5,6]. However, the growth of ecotourism in Belize presents challenges, particularly in ensuring its long-term sustainability [7]. The expansion of tourism activities carries the risk of overuse and degradation of natural resources, displacement of local communities, and the commodification of culture [8]. Therefore, it is crucial to identify and monitor indicators of sustainable ecotourism in Belize to ensure that tourism contributes to the country's economic development and conservation efforts while minimizing negative impacts on the environment and society.

Sustainable ecotourism has gained prominence in recent years as the tourism industry's growth places increasing pressure on natural resources and ecosystems. Ecotourism offers a solution by promoting conservation and sustainable development through responsible travel to natural areas, benefiting both the environment and local communities. Key aspects of sustainable ecotourism include community involvement and empowerment, conservation management, environmental education, and economic benefits for local communities [8,9]. Methods to promote sustainable ecotourism encompass certification programs, stakeholder engagement, sustainable tourism planning, and monitoring and evaluation of tourism impacts [10,11]. Additionally, applying technologies such as geographic information systems (GISs) and remote sensing facilitates the assessment and management of tourism sites [12–14]. Multi-criteria decision-making (MCDM) methods play a vital role in sustainable ecotourism research, allowing the evaluation and comparison of alternatives based on multiple criteria [15]. These methods consider various environmental, economic, social, and cultural factors that impact ecotourism sustainability [16]. MCDM methods enable decision makers to prioritize criteria, identify trade-offs, and generate comprehensive rankings of alternatives [17,18]. Various tools, such as the analytic hierarchy process (AHP), the Technique for Order of Preference by Similarity to Ideal Solution (TOPSIS), and the Preference Ranking Organization Method for Enrichment of Evaluations (PROMETHEE), have been utilized in ecotourism research to identify the most sustainable alternatives based on different criteria, assisting policymakers and stakeholders in making informed decisions to promote sustainable ecotourism development [19].

Belize, renowned for its abundant biodiversity and cultural heritage, has emerged as a sought-after ecotourism destination. Ecotourism, which emphasizes preserving and celebrating the natural environment and local culture, has gained popularity among Belize travelers. In this study, our objective is to explore sustainable ecotourism indicators specific to Belize. When it comes to identifying a comprehensive set of indicators for sustainable ecotourism, the integrated Fuzzy Delphi and Fuzzy DEMATEL approach provides distinct advantages over other methods. This approach stands out because it addresses the inherent uncertainties and subjectivities associated with indicator selection. By incorporating the Fuzzy Delphi method, expert opinions and subjective judgments can seamlessly integrate into the process, ensuring a well-rounded and inclusive perspective.

Moreover, the Fuzzy DEMATEL method enables an assessment of the interrelationships and dependencies among the identified indicators. This aspect is crucial in the complex context of ecotourism, where numerous factors interact and influence sustainability outcomes. By uncovering these intricate relationships, decision makers gain a holistic understanding of how indicators interplay, leading to a more integrated and coherent set of indicators that reflect the multidimensional nature of sustainable ecotourism in Belize. The integration of the Fuzzy Delphi and Fuzzy DEMATEL approaches also addresses the limitations of both individual methods. The Fuzzy Delphi method's potential biases in expert opinions and the Fuzzy DEMATEL method's sensitivity to threshold values are effectively mitigated by combining the two approaches. This integration results in a robust and reliable set of indicators, enhancing the accuracy and practicality of the chosen indicators for guiding sustainable ecotourism practices in Belize.

With the growing awareness of the detrimental effects of tourism on the environment and local communities, the notion of sustainability has gained significant prominence in the tourism industry. In line with this, the present study aims to address two specific research questions in the context of Belize:

(i) What are the key sustainable ecotourism indicators in the context of Belize?

(ii) What is the interdependence among these indicators?

By answering these questions, this study seeks to contribute to the understanding and promotion of sustainable practices within the ecotourism sector in Belize as per the following perspectives:

(i) This study contributes to the field of sustainable ecotourism in Belize by developing a comprehensive set of indicators using the integrated Fuzzy Delphi and Fuzzy DEMATEL approach. These indicators cover dimensions such as environmental conservation, community involvement, cultural preservation, and economic benefits.

(ii) The proposed method represents a methodological advancement in identifying and evaluating sustainable ecotourism indicators. The Fuzzy Delphi method enables the incorporation of expert opinions and subjective judgments, allowing for a more comprehensive and inclusive approach to indicator selection. On the other hand, the Fuzzy DEMATEL method facilitates the assessment of interrelationships and dependencies among the identified indicators, providing insights into their complex interactions.

(iii) By identifying the key sustainable ecotourism indicators, this research offers valuable guidance for decision-making processes, policy formulation, and the development of sustainable tourism practices. Stakeholders can utilize the results of this study to prioritize their efforts, allocate resources effectively, and implement strategies that ensure the long-term sustainability of ecotourism in Belize. Furthermore, the comprehensive set of indicators can serve as a benchmark for monitoring and evaluating the performance and progress of ecotourism initiatives, facilitating continuous improvement and adaptation.

The following is the structure of this study. Section 2 is devoted to a review of the literature. Section 3 describes the research process and methods. The discussions and results of empirical analysis are presented in Section 4. Finally, Section 5 summarizes the conclusion, implications, limitations and furture research.

2. Literature Review

2.1. Literature Review on Sustainable Ecotourism Indicators

Ecotourism has been widely recognized as a sustainable form of tourism that supports conservation efforts, promotes environmental awareness, and provides socioeconomic benefits to local communities. However, various ecotourism activities have negatively impacted the local environment, culture, and society. Therefore, identifying and implementing sustainable ecotourism indicators are essential to ensuring that ecotourism activities are sustainable in the long run.

Several studies have been conducted to assess and evaluate sustainable ecotourism indicators, employing various methods and approaches.

In a study by Ocampo et al. [20], the Fuzzy Delphi method was utilized to identify sustainable ecotourism indicators. Initially, they started with 666 tourism indicators and then tailored them specifically to ecotourism, resulting in 59 indicators. A final set of 39 indicators was derived through further refinement, aligning with the specific context of Philippine ecotourism. This research highlights the effectiveness of the Fuzzy Delphi method in narrowing down and customizing indicators to suit the requirements of sustainable ecotourism practices. Sobhani et al. [21] conducted a notable study assessing sustainable ecotourism indicators in Tehran, Iran. Their research encompassed three main categories: environmental–physical, demographic–social, and economic–institutional. Within these categories, a total of 38 environmental–physical indicators, 42 demographic–social indicators, and 30 economic–institutional indicators were identified.

In a study focused on monitoring ecotourism sustainability in the northern forests of Iran, Godratollah Barzekar et al. [22] used the Delphi process to achieve consensus on nine criteria and identified a total of 61 indicators. These indicators cover various dimensions, including ecology, economy, society, culture, and institutions, specific to the northern forests of Iran. Azlizam Aziz et al. [23] utilized the Delphi method to determine criteria and indicators for monitoring ecotourism sustainability. Through a consensus-based approach, they identified 21 environmental factors, 8 economic factors, 6 cultural factors, 21 societal factors, and 5 institutional factors. This study highlights the multidimensional nature of ecotourism sustainability assessment. Meanwhile, Asadpourian et al. [24] conducted a comprehensive analysis in Lorestan Province, Iran, using a combination of the SWOT analysis and AHP. Their integrated approach resulted in a framework consisting of 30 indicators across three dimensions: economic, social, and environmental. This study demonstrates the importance of considering multiple dimensions and employing robust analytical processes in the identification of indicators for sustainable ecotourism.

These above-mentioned studies collectively contribute to the understanding and evaluation of sustainable ecotourism indicators by employing different methodologies and approaches. They provide valuable insights into indicator selection, customization, and assessment across various dimensions, supporting the development and implementation of sustainable ecotourism practices in different regions. After comprehensively summarizing the literature on sustainable ecotourism indicators, it is evident that a wide range of approaches and methodologies have been employed to assess and evaluate the sustainability of ecotourism ventures. Within this body of research, the authors have identified six distinct groups of indicators utilized in different studies. These indicator groups encompass various dimensions and aspects of sustainable ecotourism, providing a holistic perspective on the environmental, social, cultural, economic, political, and intrinsic dimensions. The following sections delve into each group, highlighting their respective characteristics and contributions to assessing sustainable ecotourism in Table 1.

Table 1. Potential list of sustainable ecotourism indicators.

Main Dimensions	Code	Indicators
Environmental [25–28]	EN 1	Number of endangered species and protection/conservation of flora and fauna.
	EN 2	Cleanliness and quality of tourism facilities, and access to drainage and wastewater treatment systems.
	EN 3	Climate/weather and quality of air, water, and land.
	EN 4	Environmental codes of conduct, awareness, and education for tourists.
	EN 5	Environmental emergency action plans.
	EN 6	Environmental laws and sites' rules and regulations.
	EN 7	Environmentally responsible suppliers.
	EN 8	Negative impacts of tourism on the environment.
	EN 9	Proper use and consumption of water.
	EN 10	Proper use of electrical power.
	EN 11	Recycling, reduction, and reuse of waste.
	EN 12	Respect of ecosystem and proper use of coastal land and forest with every new development project.
	EN 13	Restoration and reduction of damage caused by tourism.
	EN 14	Use of biodegradable products.
	EN 15	Water, land, and air pollution.
	EN 16	Workshops and discussions on environmentally friendly management techniques.

Table 1. *Cont.*

Main Dimensions	Code	Indicators
Social [29–33]	SO 1	Disability laws.
	SO 2	Exploitation of employees, child labor, or sex tourism.
	SO 3	Fair compensation and compliance with labor laws.
	SO 4	Impacts of tourists on local issues.
	SO 5	Improvement of well-being, quality of life, and safety of local community.
	SO 6	Level of interaction between locals and tourists.
	SO 7	Local business support.
	SO 8	Organizational structure inclusivity.
	SO 9	Poverty risk and social exclusion.
	SO 10	Professional development and education of locals.
	SO 11	Protection of minority groups.
	SO 12	Social equity in all organizational practices.
	SO 13	Stakeholder rights regarding tourist activities.
	SO 14	Training and promotion of qualified employees within the tourism industry.
Cultural [24,33–36]	CU 1	Authenticity of local products and services.
	CU 2	Availability and accessibility of information about local culture.
	CU 3	Cultural codes of conduct for tourists.
	CU 4	Illegal trade of artifacts.
	CU 5	Negative effects of development projects on cultural identities.
	CU 6	Promotion and protection of local culture.
Economic [25,37–40]	EC 1	Ability to attract more investment.
	EC 2	Availability and accessibility of medical services, transportation, and recreational facilities.
	EC 3	Conservation of local economy pace.
	EC 4	Cost management of tourism operations.
	EC 5	Domestic spending, reinvestment, and business expansion.
	EC 6	Economic and financial development of stakeholders.
	EC 7	Employment opportunities, financial subsidization, and compensation for locals.
	EC 8	Fair trade practices and principles.
	EC 9	Implementation of green design technology.
	EC 10	Risk management and production stabilization.
	EC 11	Satisfactory goods and services.
	EC 12	Support and contribution towards development of local goods, services, and infrastructure.
	EC 13	Support for local suppliers and subsidization of local production and manufacturing.
	EC 14	Taxes on land, buildings, and other structures.
	EC 15	Tourist expenditure and annual gross income in tourism jobs.

Table 1. *Cont.*

Main Dimensions	Code	Indicators
Political [25,41–43]	PO 1	Foreign involvement and ownership in local business.
	PO 2	Common organizational goals and employee loyalty and job security.
	PO 3	Democratic organizational cultures, group management, autonomy, flexibility, freedom of speech, and participatory decision making.
	PO 4	Ethical, moral, and transparent organizational structures.
	PO 5	Monitorization of operational, management, and financial results.
	PO 6	Political prejudices, bias, and discrimination.
	PO 7	Reflection of sustainability values on business practices.
Intrinsic [37,44]	IN 1	Attitude of locals toward satisfaction, service quality, and training mechanisms.
	IN 2	Average length of stay per tourist.
	IN 3	Crime rates, accidents, visitor safety and security, and legal compliance (prosecutions, fines, etc.).
	IN 4	Overall service quality of local businesses and potential businesses.
	IN 5	Tourist satisfaction with related activities and the volume of tourists, returning tourists, and seasonality.

The environmental dimension is a vital aspect of sustainable ecotourism, aiming to promote the conservation and protection of the environment [25–27]. Evaluating the environmental impact of ecotourism activities requires using indicators that assess sustainability. Several critical indicators have been identified in the literature. These indicators include the protection and conservation of endangered species, the cleanliness and quality of tourism facilities, climate and weather conditions, environmental codes of conduct and tourist awareness, environmental emergency action plans, and adherence to environmental laws and regulations. Additionally, the use of environmentally responsible suppliers and the implementation of restoration measures to reduce damage caused by tourism are essential factors. By implementing sustainable practices, such as ecotourism, it is possible to mitigate the negative impact of tourism activities on the environment and contribute to environmental sustainability. Monitoring and evaluating these indicators are essential for the successful development of sustainable ecotourism.

The social dimension of sustainable ecotourism encompasses a range of indicators that focus on the well-being of local communities, human rights, and social equity [28–30]. It recognizes both the potential benefits of tourism for local people and the risks of negative impacts on their livelihoods, culture, and identity. Key social indicators include compliance with disability laws to ensure accessibility and inclusivity, prevention of exploitation of employees, consideration of local issues and tensions between tourists and communities, support for local businesses and entrepreneurship, inclusive organizational structures, poverty reduction and avoidance of social exclusion, professional development and education opportunities for locals, protection of minority groups and cultural heritage, social equity in all organizational practices, recognition of stakeholder rights, and training and promotion of qualified employees. These indicators highlight the importance of fostering positive social impacts, respecting local rights and traditions, and promoting equitable participation and benefits for all stakeholders involved in ecotourism.

The cultural dimension is a critical aspect of sustainable ecotourism, encompassing indicators focusing on preserving and promoting local cultures [24,31]. Cultural indicators play a significant role in creating authentic tourist experiences, fostering economic growth for local businesses, and respecting the values and beliefs of the host community. Key cultural indicators include the authenticity of local products and services, availability and accessibility of information about local culture, cultural codes of conduct for tourists, addressing the issue of the illegal trade of artefacts, mitigating negative impacts of development projects on cultural identities, and promoting and protecting local culture through festivals, handicrafts, and cuisine. These indicators emphasize the importance of preserving cultural heritage, preventing misrepresentation, and ensuring sustainable development that respects the cultural identity of the host community.

The economic dimension is a vital aspect of sustainable ecotourism, focusing on indicators that assess the financial sustainability and contribution of ecotourism to the local economy [25,32]. Economic indicators evaluate factors such as the ability to attract investment, availability and accessibility of essential services and facilities, conservation of the local economy's pace, cost management of tourism operations, domestic spending and business expansion, economic and financial development of stakeholders, employment opportunities and compensation for locals, fair trade practices, implementation of green design technology, and risk management and production stabilization. These indicators help measure the economic benefits, employment generation, financial well-being, and the region's long-term viability. Effective risk management practices and production stabilization are crucial for managing potential risks and maintaining consistent quality, ultimately enhancing customer satisfaction and attracting more visitors. Monitoring and evaluating economic indicators enable ecotourism operators to make informed decisions and improve their economic sustainability.

The political dimension is a vital component in assessing the sustainability of ecotourism, as it examines the political climate of the destination and its impact on the industry [33–35]. Political indicators play a significant role in evaluating various aspects such as foreign involvement and ownership in local businesses, common organizational goals and employee loyalty, democratic organizational cultures and participatory decision making, ethical and transparent organizational structures, monitoring of operational and financial results, political prejudices and discrimination, and the reflection of sustainability values in business practices. These indicators help identify areas for improvement, promote sustainable practices, and ensure the industry's long-term viability. By addressing political factors and fostering an environment of collaboration, transparency, and ethical responsibility, ecotourism can thrive while benefiting the local community and preserving the natural and cultural heritage of the destination.

The intrinsic dimension of sustainable ecotourism indicators focuses on measuring aspects inherent to the tourism industry, providing valuable information about service quality and tourist satisfaction [36,37]. These indicators encompass various factors such as the attitude of locals towards service quality and training mechanisms, the average length of stay per tourist, crime rates and visitor safety, the overall service quality of local businesses, and tourist satisfaction with related activities. By assessing these intrinsic indicators, stakeholders can gain insights into the effectiveness of training programs, marketing campaigns, safety measures, and service quality. This information can guide efforts to enhance the tourism experience, attract more visitors, and foster repeat visits, ultimately contributing to ecotourism destinations' long-term sustainability and success.

2.2. Literature Review on Established Methods

In order to effectively assess and analyze the multitude of variables and factors involved in sustainable ecotourism, a robust and systematic method is essential to filter and prioritize these variables. This ensures that the indicators used for evaluation are relevant, comprehensive, and representative of the sustainability dimensions. Focusing on different aspects of methodology in the field of environmental modeling and sustainability assessment, Pianosi et al. [45] discussed the concept of sensitivity analysis (SA) and its applications in environmental modeling. Andria et al. [46] presented a fuzzy approach for assessing the sustainability of tourist destinations, addressing the limitations of the traditional carrying capacity method. In another study, Andria et al. [47] emphasized the increasing importance of "smartness" and "sustainability" in decision-making processes for practitioners and policymakers. Finally, Andria et al. [48] presented a method for ranking tourist destinations and evaluating their sustainability performance. They employed a fuzzy multiple-criteria decision-making method to determine sustainability performance values and rank destinations accordingly. These studies collectively highlight the significance of incorporating fuzzy approaches and sensitivity analysis techniques for robust sustainability assessment in various domains, including environmental modeling and tourist destinations.

Of the numerous methods utilized in academic literature, the Delphi technique has gained prominence as a widely accepted and efficient method for achieving consensus on a particular subject. This method enables the systematic collection of expert opinions on a particular subject through sequentially applied feedback questionnaires interspersed with summary data on earlier responses [49]. The Delphi method, recognized as a dependable qualitative research strategy, can address challenges, enhance decision making, and foster consensus among groups in diverse domains [50]. It can be identified by four key characteristics: participant anonymity, iterative rounds of feedback and opinion revision, controlled feedback that informs participants about the perspectives of others, and the provision for Delphi participants to clarify or modify their views. Furthermore, the method enables quantitative analysis and interpretation of data through statistical group responses [51]. A loss of individual knowledge occurs as a result of the Delphi method's requirement that experts adjust their judgments to reflect the average worth of all expert opinions. Furthermore, the Delphi technique does not consider data imprecision and uncertainty. Therefore, using a defuzzifyng function based on questionnaires, the conventional Delphi approach is combined with fuzzy sets to validate essential elements and choose assessment indicators [52–55]. In order to deal with uncertainty and imprecision, fuzzy theory is a mathematical framework that permits variables to have partial membership in a set. This implies that fuzzy theory allows for more nuanced and probabilistic explanations of variables as opposed to utilizing binary true/false values, which can be advantageous when working with complicated or ambiguous concepts. When dealing with linguistic variables, such as "high" or "low" levels of a given factor, fuzzy theory is constructive since it enables varying degrees of membership in a collection rather than requiring a binary classification [55]. Evaluating the relationship between indicators is crucial in assessing sustainable ecotourism, as it allows for a deeper understanding of the complex interactions and dependencies among different indicators. The Delphi technique and the DEMATEL approach have both been widely used to study the cause-and-effect linkages between indicators and provide a systematic framework for assessing their interdependencies [56,57]. The Delphi method helps generate expert consensus and identify relevant indicators, while DEMATEL offers a quantitative analysis of the relationships between these indicators. Additionally, Fuzzy DEMATEL, an extension of DEMATEL that incorporates fuzzy logic, has been utilized to address uncertainties and vagueness in the assessment process [58,59]. These two methods have been effective in various fields, allowing researchers to gain valuable insights into the complex relationships among indicators and their implications for sustainable development [60–62]. Therefore, considering the significance of these methods, applying Fuzzy Delphi–DEMATEL in the context of sustainable ecotourism can provide valuable insights for decision making and policy formulation.

2.3. Research Gaps

With its rich biodiversity and significant ecotourism potential, Belize presents a unique case for exploring the relationships between indicators and identifying priority areas for intervention. Despite the extensive research on sustainable ecotourism indicators, there is still a notable research gap regarding a comprehensive assessment of variables and their interrelationships. Moreover, a limited number of studies have explicitly focused on the context of Belize, an ecologically diverse and significant ecotourism destination. Therefore, this work aims to address these research gaps by applying the combined methods of Fuzzy Delphi and Fuzzy DEMATEL in the context of sustainable ecotourism in Belize. This study seeks to comprehensively analyze indicators, evaluate their interdependencies, and offer valuable insights for sustainable ecotourism development in Belize by utilizing these methods. This research's findings can contribute to the body of knowledge and offer practical guidance for policymakers, stakeholders, and ecotourism professionals in Belize and elsewhere.

3. Methodology

3.1. Research Process

The research process involves three phases, as presented in Figure 1 as follows:

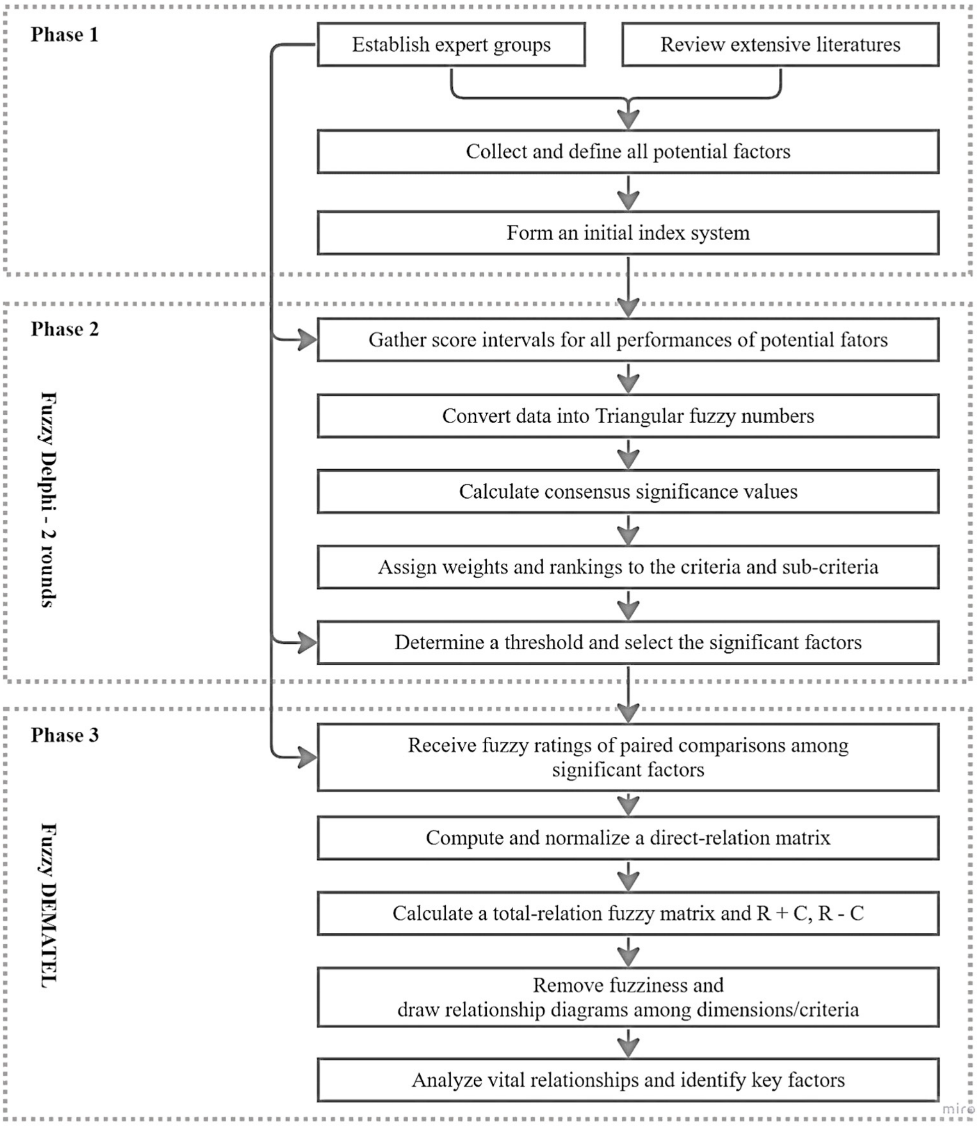

Figure 1. Research framework.

In the first phase, potential indicators are collected from literature review and experts' opinions to build an initial index system. This phase focuses on gathering relevant information and establishing a foundation for the subsequent analysis.

In the second phase, the Fuzzy Delphi method is employed to recognize significant factors. Expert groups are surveyed through a questionnaire, and consensus significance values are calculated to validate critical factors. The significance of factors is determined based on their level of influence. It is important to note that qualitative data are transformed into quantitative data using linguistic terms transformation (refer to Table 2). Two rounds of Fuzzy Delphi are conducted to enhance the reliability and accuracy of the results.

Table 2. TFNs corresponding to linguistic terms of Fuzzy Delphi method.

Linguistic Terms	TFNs
Equal	(0, 0, 0.25)
Moderate	(0, 0.25, 0.5)
Strong	(0.25, 0.5, 0.75)
Demonstrated	(0.5, 0.75, 1)
Extreme	(0.75, 1, 1)

In the third phase, a causal structure model is developed using the Fuzzy DEMATEL method to identify critical factors. This involves analyzing the causal relationships between the significant factors. The Fuzzy DEMATEL method allows for a comprehensive understanding of the interdependencies and correlations among the identified factors.

This hybrid framework offers several advantages, including the incorporation of vague judgments into quantitative values, integration of expert comments, and the ability to explore correlations between factors under uncertain circumstances. It is well suited for addressing real-world decision-making issues, particularly in the context of identifying indicators for sustainable ecotourism in Belize.

3.2. Fuzzy Delphi Method

The integration of the Delphi method with fuzzy set theory, known as Fuzzy Delphi, offers several advantages, including facilitating consensus among diverse perspectives, saving time and cost, and reducing the number of rounds required for opinion collection [63]. In this study, to better capture and represent expert knowledge, triangular fuzzy numbers (TFNs) are employed. TFNs are characterized by three actual numbers (l, m, u), where l represents the lower limit, m represents the maximum, and u represents the upper limit. The use of TFNs enhances decision-making capabilities in complex problem-solving scenarios [64].

Step 1: Given P experts and Q attributes, where expert i (P_i = 1, 2, 3, . . . , n) concludes that characteristic j (Q_j = 1, 2, 3, . . . , m) can be represented as a TFN, F_{ij} = (l_{ij}; m_{ij}; u_{ij}). In this representation, l_{ij} denotes the lower limit, m_{ij} denotes the modal value, and u_{ij} denotes the upper limit of the TFN. As a consequence, linguistic values are produced utilizing linguistic words and TFNs, as illustrated in Table 2.

The weight of attribute j then refers to F_{ij} = (l_{ij}; m_{ij}; u_{ij}) where $\left[l_{ij} = min\left(l_{ij}\right); m_{ij} = \sqrt[n]{\prod_1^n m_{ij}}; u_{ij} = max\left(u_{ij}\right)\right]$.

Step 2: The convex combination value and the alpha cut value are distinct approaches for summarizing and interpreting TFNs in fuzzy systems [64]. The convex combination value of a TFN involves calculating a weighted average that considers the membership levels at different points along its range. It provides a single representative value that captures the general information of the TFN, taking into account its entire shape. This method enables a more nuanced representation of experts' opinions, facilitating decision making and analysis. In contrast, the alpha cut value of a TFN focuses on a specific level of membership or confidence. It determines the crisp value at which the TFN possesses a certain degree of membership. By identifying the point or interval along the x-axis where the membership function exceeds a predefined threshold (α), the alpha cut value provides a crisp value suitable for crisp decisions or comparisons [65].

In this study, the convex combination value of TFNs is employed as a method to merge multiple TFNs into a unified value. To determine the convex combination value, a parameter λ is introduced, where λ is adjusted between 0 and 1 based on the experts' perceptions, whether they are positive or negative, and in accordance with the average judgments of the expert group. This adjustment ensures that the resulting value aligns with the collective opinions and reflects the level of consensus among the experts. By utilizing a parameter λ (in this study, λ = 0.5), the convex combination value $D_b(\alpha_b, \beta_b)$ is obtained using Equation (1):

$$\begin{aligned} \alpha_b &= u_b - \lambda(u_b - m_b) \\ \beta_b &= l_b - \lambda(m_b - l_b) \end{aligned} \tag{1}$$

Step 3: Next, the precise value of $D_b(\alpha_b, \beta_b)$ is calculated using Equation (2):

$$D_b = \int(\alpha_b, \beta_b) = \lambda[\alpha_b + (1-\lambda)\beta_b] \tag{2}$$

Step 4: The threshold for the valid attributes is generated using Equation (3):

$$Therehold(\text{б}) = \sum_{a=1}^{n} \frac{D_b}{n} \tag{3}$$

The attribute b is acceptable if D_b > б, but it is refused if D_b < б, according to [66].

3.3. Fuzzy DEMATEL Method

DEMATEL is a reliable technique for analyzing causal correlations and significant effects among attributes [67]. This method incorporates expert opinions, which are initially expressed qualitatively and then converted into fuzzy numbers to eliminate ambiguity and achieve a shared perspective. Notably, the Fuzzy DEMATEL approach utilizes the total-relation matrix to identify linkages between criteria and subcriteria, as well as cause-and-effect relationships [68,69]. One of the key advantages of this method is its reliance on pairwise comparisons, enabling the consideration of relationships during the decision-making process [70,71].

The experts express their judgments regarding the relationships between attributes on a 5-point linguistic scale (Table 3).

Table 3. TFNs corresponding to linguistic terms of Fuzzy DEMATEL method.

Linguistic Terms	TFNs
No effect	(0, 0, 0.25)
Extremely weak effect	(0, 0.25, 0.5)
Weak effect	(0.25, 0.5, 0.75)
Strong effect	(0.5, 0.75, 1)
Extremely strong effect	(0.75, 1, 1)

Step 1: The fuzzy weight (E_{kij}), assigned by the k^{th} expert, represents the level of influence of the i^{th} attribute on the j^{th} attribute in a decision committee based on a 5-point linguistic scale (Table 3). It is expressed using TFNs or linguistic terms to capture the expert's subjective perception. These fuzzy TFNs quantify the expert's opinion and contribute to the decision-making process by considering their expertise and knowledge of the assessed attributes using Equations (4) and (5).

$$E_{kij} = \left(l_{ij}^k, m_{ij}^k, u_{ij}^k\right) \tag{4}$$

$$E_{kij} = \left[\frac{l_{ij}^k - min\ l_{ij}^k}{max\ u_{ij}^k - min\ l_{ij}^k}, \frac{m_{ij}^k - min\ m_{ij}^k}{max\ u_{ij}^k - min\ l_{ij}^k}, \frac{u_{ij}^k - min\ u_{ij}^k}{max\ u_{ij}^k - min\ l_{ij}^k},\right] \tag{5}$$

Step 2: The left (Lv) and right (Rv) values are transformed into normalized values, as indicated in Equation (6). These normalized values are subsequently utilized to calculate the total normalized crisp values (Cv), as illustrated in Equation (7).

$$(Lv_{ij}, Rv_{ij}) = \left(\frac{m_{ij}^k}{1 + m_{ij}^k - l_{ij}^k}, \frac{u_{ij}^k}{1 + u_{ij}^k - m_{ij}^k} \right) \tag{6}$$

$$Cv_{ij}^k = \frac{\left[Lv_{ij}\left(1 - Lv_{\ ij}\right) + Rv_{ij} \right]}{\left(1 - Lv_{\ ij} + Rv_{ij}\right)} \tag{7}$$

Step 3: A synthetic value is obtained to calculate the individual judgment of each expert using Equations (8)–(10):

$$X_{ij}^k = min\ Rv_{ij} - Cv_{ij}^k \left(max\ u_{ij}^k - min l_{ij}^k \right) \tag{8}$$

$$Z_{ij}^k = \frac{\left(X_{ij}^1 + X_{ij}^2 + X_{ij}^3 + \ldots + X_{ij}^n \right)}{k} \tag{9}$$

$$Z_{ij}^k = \left(l_{ij}^Z, m_{ij}^Z, u_{ij}^Z \right) \tag{10}$$

Step 4: The direct-relation fuzzy matrix is normalized using Equations (11) and (12):

$$r = max \sum_{j=1}^{k} u_{ij}^Z \tag{11}$$

$$\widetilde{H}_{ij} = \frac{Z_{ij}^k}{r} = \left(\frac{l_{ij}^Z}{r}, \frac{m_{ij}^Z}{r}, \frac{u_{ij}^Z}{r} \right) = \left(l''_{\ ij}, m''_{\ ij}, u''_{\ ij} \right) \tag{12}$$

Step 5: The total-relation fuzzy matrix (T) is determined using Equations (13)–(17):

$$T = \lim_{k \to \infty} \left(\widetilde{H}^1, \widetilde{H}^2, \widetilde{H}^3 \right) \tag{13}$$

$$\widetilde{t}_{ij} = \left(l_{ij}^t, m_{ij}^t, u_{ij}^t \right) \tag{14}$$

$$l_{ij}^t = H_l \times (I - H_l)^{-1} \tag{15}$$

$$m_{ij}^t = H_m \times (I - H_m)^{-1} \tag{16}$$

$$u_{ij}^t = H_u \times (I - H_u)^{-1} \tag{17}$$

Step 6: The total-relation fuzzy matrix (TM) is defuzzified using Equation (18).

$$t_{ij} = \frac{l_{ij}^t + 2m_{ij}^t + u_{ij}^t}{4} \tag{18}$$

Step 7: The R value and C value are calculated using variables retrieved from the total-relation defuzzified matrix using Equations (19) and (20).

$$\mathrm{R_j} = \sum_{\mathrm{j=1}}^{\mathrm{n}} \mathrm{t_{ij}} (\mathrm{j} = 1, 2, 3, \ldots, \mathrm{n}) \tag{19}$$

$$C_i = \sum_{i=1}^{n} t_{ij} (i = 1, 2, 3, \ldots, n) \tag{20}$$

The number of elements in each row (R_j) shows how much one component impacts other factors in the system. On the other hand, the number of components in each column (C_i) reveals how much other systemic factors influence a factor.

Step 8: Drawing cause/effect interrelationship:

The cause/effect interrelationships can be visualized by plotting the values of ($R_j + C_i$) and ($R_j - C_i$) on a Cartesian coordinate system. The ($R_j + C_i$) values represent the degree of interaction between a specific factor and other factors in the system, with higher values indicating stronger interactions. Conversely, the ($R_j - C_i$) values indicate the strength of the causal relationship, with positive values indicating the factor as a cause and negative values indicating it as an effect.

To create an influential relation map (IRM), the defuzzified values are used in Equations (21) and (22) to determine the influence level among the different aspects.

$$p = \frac{\sum_{n=1}^{n} t_{ij}}{TM^2} \tag{21}$$

where p is the threshold to filter the influence between two aspects. If $t_{ij} > p$, then there is interaction between two aspects, and the influence level is t_{ij}.

$$\text{influence level} = \begin{cases} t_{ij} < p : weak \\ weak < t_{ij} < \frac{p_1 + p_2}{2} : medium \\ t_{ij} > p : strong \end{cases} \tag{22}$$

where $p_1 = \frac{\sum_{n=1}^{n} t_{ij}}{count(t_{ij} > p)}$ and $p_2 = \max(t_{ij})$.

4. Results

4.1. Expert Panel

The selection of participants is a crucial step in implementing the Delphi technique. Niederberger et al. [69] emphasized the importance of creating a well-balanced panel by exercising judgment to include experts from diverse backgrounds. The individuals invited to participate should possess a deep understanding of the topic at hand. The number of respondents should be neither too small, as this may limit the breadth of evaluation, nor too large, as this may become challenging to coordinate. A sample size of 10 to 20 experts is generally considered sufficient to generate meaningful outcomes [53]. Nguyen et al. [70] further highlighted that a Delphi group instills greater confidence when comprising at least 10 experts.

The authors emphasize the importance of gathering credible opinions from a powerful group of experts in order to develop a framework for addressing indicators related to sustainable ecotourism. To ensure the accuracy of the data and research results, a diverse range of experts, including government officials, tourism organizations, SMEs, ecologists, tourism specialists, and sustainable development practitioners, should be involved in the decision-making process. The methodology presented in this paragraph demonstrates a collaborative and interdisciplinary approach to addressing various factors promoting sustainable ecotourism. The authors invited 20 qualified respondents from various backgrounds to participate in a communication meeting, providing their opinions on the importance and relationships of indicators in sustainable ecotourism. By incorporating a wide range of perspectives and expertise, the researchers aim to develop a comprehensive framework that considers the needs and priorities of all stakeholders involved in sustainable ecotourism. Table 4 summarizes the profiles of the experts.

Table 4. The general information of 20 respondents.

Information	Item	Frequency	Percentage
Age	From 25 to 40 From 40 to 60 Over 60	3 9 8	15 45 40
Gender	Male Female	8 12	40 60
Education	Bachelor Master Doctor	3 8 8	15 40 40
Position occupation	Scholar Policymaker Manager	8 7 5	40 35 25
Experience	5–10 years 10–20 years Over 20 years	8 6 6	40 30 30

4.2. Fuzzy Delphi Results

The Fuzzy Delphi analysis is conducted in two rounds. The importance of each factor is represented by the absolute mean of the experts' agreement, as displayed in Table 5. In the first round, with a threshold of б = 0.301, 9 out of 63 elements were eliminated. A threshold of б = 0.304 was used in the second round, removing 3 additional elements from the initial set of 63.

Table 5. Fuzzy Delphi method results.

Dimensions	Criteria	Round 1		Round 2		Accepted Criteria
		Weight	Validate	Weight	Validate	
Environmental	EN 1	0.3235	Accept	0.3387	Accept	EN 1
	EN 2	0.2210	Reject			
	EN 3	0.3226	Accept	0.3178	Accept	EN 3
	EN 4	0.3120	Accept	0.3090	Accept	EN 4
	EN 5	0.2222	Reject			
	EN 6	0.3246	Accept	0.3051	Accept	EN 6
	EN 7	0.3283	Accept	0.3087	Accept	EN 7
	EN 8	0.3018	Accept	0.1563	Reject	
	EN 9	0.3225	Accept	0.3267	Accept	EN 9
	EN 10	0.3231	Accept	0.3164	Accept	EN 10
	EN 11	0.3073	Accept	0.3374	Accept	EN 11
	EN 12	0.3220	Accept	0.3196	Accept	EN 12
	EN 13	0.3136	Accept	0.3107	Accept	EN 13
	EN 14	0.3145	Accept	0.3216	Accept	EN 14
	EN 15	0.3261	Accept	0.3225	Accept	EN 15
	EN 16	0.3272	Accept	0.3145	Accept	EN 16
Social	SO 1	0.1250	Reject			
	SO 2	0.3029	Accept	0.2210	Reject	
	SO 3	0.3149	Accept	0.3257	Accept	SO 3
	SO 4	0.3162	Accept	0.3337	Accept	SO 4
	SO 5	0.3252	Accept	0.3193	Accept	SO 5
	SO 6	0.3220	Accept	0.3178	Accept	SO 6
	SO 7	0.3188	Accept	0.3155	Accept	SO 7
	SO 8	0.3192	Accept	0.3059	Accept	SO 8
	SO 9	0.3192	Accept	0.3274	Accept	SO 9
	SO 10	0.3246	Accept	0.3047	Accept	SO 10
	SO 11	0.2500	Reject			
	SO 12	0.3323	Accept	0.3248	Accept	SO 12
	SO 13	0.3299	Accept	0.3196	Accept	SO 13
	SO 14	0.3182	Accept	0.3082	Accept	SO 14

Table 5. *Cont.*

Dimensions	Criteria	Round 1		Round 2		Accepted Criteria
		Weight	Validate	Weight	Validate	
Cultural	CU 1	0.3178	Accept	0.3267	Accept	CU 1
	CU 2	0.3159	Accept	0.3176	Accept	CU 2
	CU 3	0.3094	Accept	0.3216	Accept	CU 3
	CU 4	0.3283	Accept	0.3192	Accept	CU 4
	CU 5	0.3257	Accept	0.3094	Accept	CU 5
	CU 6	0.3127	Accept	0.3090	Accept	CU 6
Economic	EC 1	0.3067	Accept	0.3172	Accept	EC 1
	EC 2	0.1250	Reject			
	EC 3	0.3263	Accept	0.3257	Accept	EC 3
	EC 4	0.3036	Accept	0.1250	Reject	
	EC 5	0.3054	Accept	0.3323	Accept	EC 5
	EC 6	0.3000	Reject			
	EC 7	0.3051	Accept	0.3111	Accept	EC 7
	EC 8	0.3129	Accept	0.3210	Accept	EC 8
	EC 9	0.1250	Reject			
	EC 10	0.3111	Accept	0.3220	Accept	EC 10
	EC 11	0.3003	Reject			
	EC 12	0.3320	Accept	0.3290	Accept	EC 12
	EC 13	0.3349	Accept	0.3192	Accept	EC 13
	EC 14	0.1250	Reject			
	EC 15	0.3014	Accept	0.3114	Accept	EC 15
Political	PO 1	0.3288	Accept	0.3212	Accept	PO 1
	PO 2	0.3202	Accept	0.3075	Accept	PO 2
	PO 3	0.3123	Accept	0.3212	Accept	PO 3
	PO 4	0.3155	Accept	0.3222	Accept	PO 4
	PO 5	0.3029	Accept	0.3164	Accept	PO 5
	PO 6	0.3078	Accept	0.3220	Accept	PO 6
	PO 7	0.3131	Accept	0.3248	Accept	PO 7
Intrinsic	IN 1	0.3272	Accept	0.3226	Accept	IN 1
	IN 2	0.3267	Accept	0.3257	Accept	IN 2
	IN 3	0.3188	Accept	0.3174	Accept	IN 3
	IN 4	0.3214	Accept	0.3127	Accept	IN 4
	IN 5	0.3059	Accept	0.3198	Accept	IN 5
		Threshold = 0.3009		Threshold = 0.3041		

In the context of sustainable ecotourism, certain indicators were eliminated from consideration in the environmental, social, and economic dimensions. Specifically, in the environmental dimension, the indicators cleanliness and quality of tourism facilities, access to drainage and wastewater treatment systems (EN2), environmental emergency action plans (EN5), and negative impacts of tourism on the environment (EN8) were excluded. In the social dimension, the indicators disability laws (SO1), exploitation of employees, child labor or sex tourism (SO2), and protection of minority groups (SO11) were disqualified. In the economic dimension, most factors were excluded, including the indicators availability and accessibility of medical services, transportation and recreational facilities (EC2), cost management of tourism operations (EC4), economic and financial development of stakeholders (EC6), implementation of green design technology (EC9), satisfactory goods and services (EC11), and taxes on land, buildings, and other structures (EC14). However, indicators in the cultural, political, and intrinsic dimensions were preserved for consideration in the sustainable ecotourism framework. In conclusion, a total of 51 elements were deemed suitable for use in the next stage of the Fuzzy DEMATEL analysis.

4.3. Fuzzy DEMATEL Results

The interrelationships among the six dimensions, namely environmental (EN), social (SO), cultural (CU), economic (EC), political (PO), and intrinsic (IN), as well as the sub-criteria within each dimension, were explained using the Fuzzy DEMATEL method. To illustrate the computational procedure for the dimensions, experts provided their opinions with fuzzy ratings based on Table 3.

In the next step, linguistic ratings were collected, and an initial integrated direct-causal-relationships fuzzy matrix was derived using Equation (4). Subsequently, the fuzzy matrix was normalized using Equations (8) and (9). The fuzzy total-relation matrix was obtained based on Equations (10)–(14). The total-relation matrix and the normalized direct-relation matrix were then generated. The R value was computed by summing the variables in each row, while the C value was calculated by summing the variables in each column. The difference between R and C represents the net influence levels, where positive values indicate that one dimension has a more significant influence on other dimensions than they have on it. Negative values indicate that the dimension is more likely to be affected by others. The R + C value represents the correlation intensity among dimensions, with higher values indicating more significant importance. The calculation process described above was applied to the main dimensions, and the results are presented in Table 6.

Table 6. The crisp total-relation defuzzified matrix.

Main Dimensions	EN	SO	CU	EC	PO	IN	R	C	R + C	R − C	Relation
EN	0.69	0.81	0.86	0.84	0.85	0.74	4.79	4.76	9.55	0.03	Cause
SO	0.78	0.69	0.80	0.87	0.84	0.71	4.69	7.91	12.60	−3.22	Effect
CU	0.78	0.80	0.71	0.82	0.86	0.73	4.70	4.47	9.17	0.23	Cause
EC	0.87	0.89	0.90	0.78	0.93	0.78	5.14	4.84	9.98	0.30	Cause
PO	0.76	0.77	0.80	0.80	0.70	0.69	4.51	8.00	12.51	−3.49	Effect
IN	0.88	0.87	0.89	0.88	0.91	0.67	5.11	4.53	9.65	0.58	Cause

The influence level of the six dimensions in the case of sustainable ecotourism in Belize can be prioritized as social (SO) > political (PO) > economic (EC) > intrinsic (IN) > environmental (EN) > cultural (CU), based on the D+R values. Based on the D−R values, environmental (EN), cultural (CU), economic (EC), and intrinsic (IN) are net causes, while the remaining dimensions are net effects.

A threshold value was determined by calculating the average of all elements in the total-relation matrix to identify significant influence relationships among the dimensions and criteria. If an element in the full influence matrix exceeded this threshold value, it indicated a higher relevance. Conversely, if the value fell below the threshold, indicating low relevance, it was removed and set to 0 in the matrix. In this specific case study, the threshold value was determined to be 0.804. Taking the second row of Table 6 as an example, the values for the economic dimension (0.87) and political dimension (0.84) surpass the threshold value. Thus, the social dimension influences both the economic dimension and the political dimension. Similarly, the influential relation map (IRM) among the dimensions was identified and is presented in Table 7. Figure 2 sets the rules for the intensity levels of the relationships, which combine three intensity levels (strong, medium, and weak). Moreover, the interdependencies and relationships among the dimensions are visually depicted in Figure 3.

Table 7. Influential relation map among dimensions.

Main Dimensions	EN	SO	CU	EC	PO	IN
EN	0.00	0.81	0.86	0.84	0.85	0.00
SO	0.00	0.00	0.00	0.87	0.84	0.00
CU	0.00	0.00	0.00	0.82	0.86	0.00
EC	0.87	0.89	0.90	0.00	0.93	0.00
PO	0.00	0.00	0.00	0.80	0.00	0.00
IN	0.88	0.87	0.89	0.88	0.91	0.00

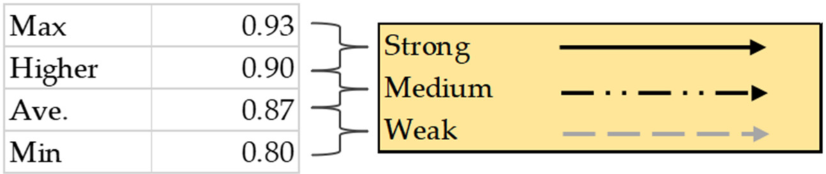

Figure 2. Intensity level of the relationships.

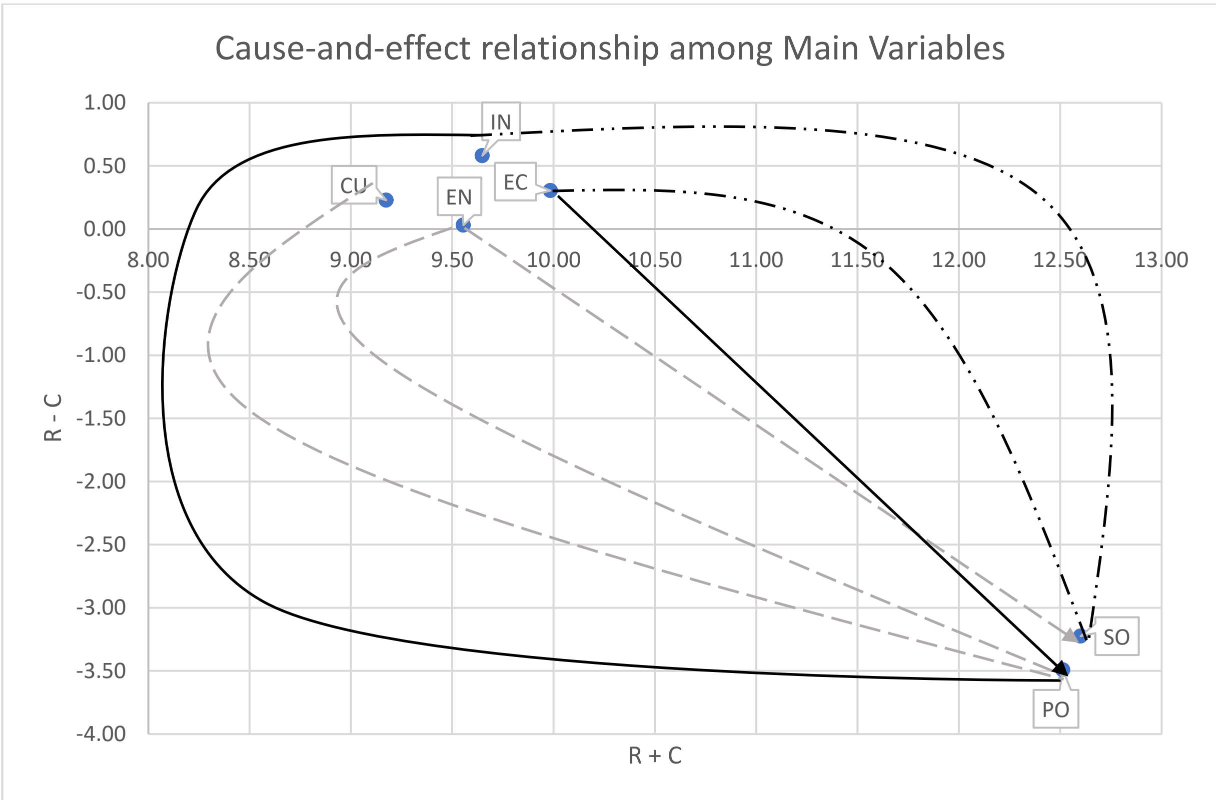

Figure 3. Significant cause/effect relationship diagram among main dimensions.

The direction of the arrow should describe the matrix. If the figure is "0", this means there is no relationship between the dimensions. For example, EN (horizontal) has relationships with SO and PO, and has no interrelationship with IN. Furthermore, dimensions under the exact cause or effect system group are not considered causality relationships, which means they are deleted. To be more specific, IN and EC substantially affect PO while having a medium effect on SO as denoted in Figures 2 and 3.

The same computational procedure of the dimensions was applied to each dimension group to show the relationships between the subcriteria within. Figures 4–9 show that the impact–relationship map in the net format of criteria under six dimensions can be plotted. The findings and analysis of the subcriteria within each dimension are outlined below according to rules in Figure 2.

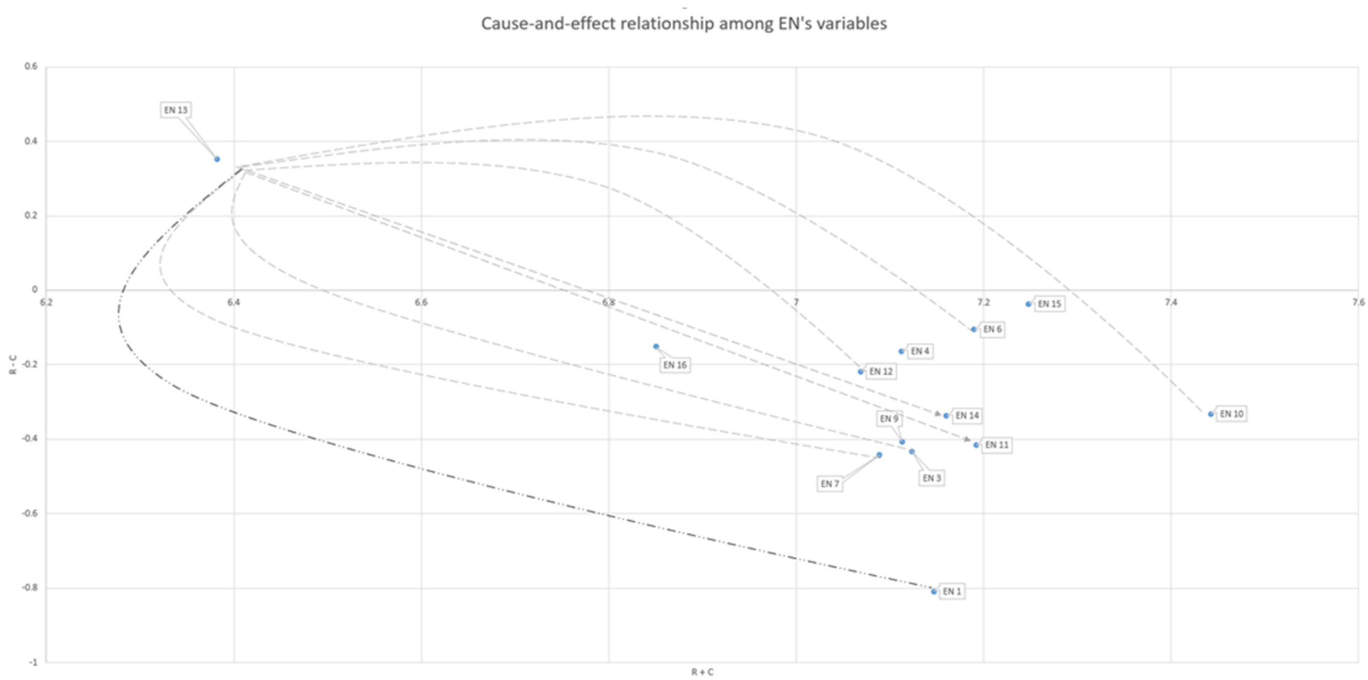

Figure 4. Impact–relation map of environmental dimension.

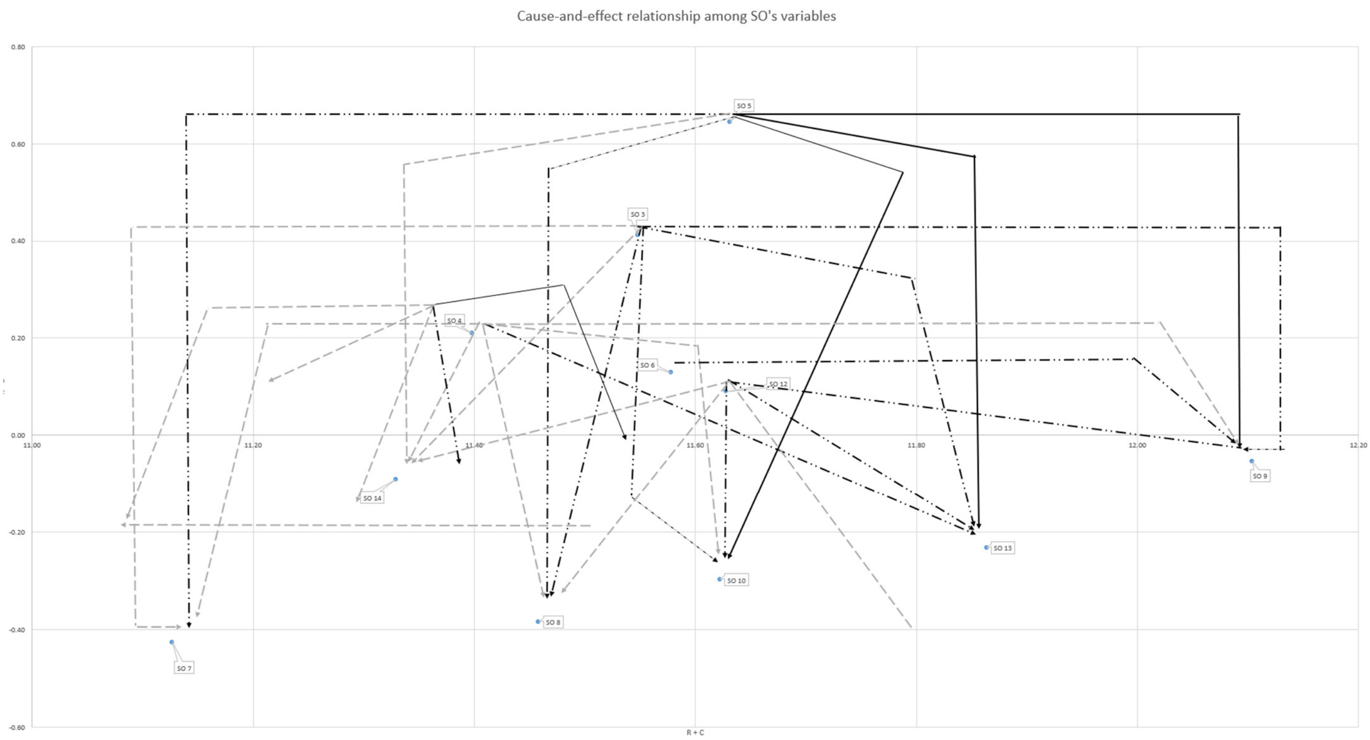

Figure 5. Impact–relation map of social dimension.

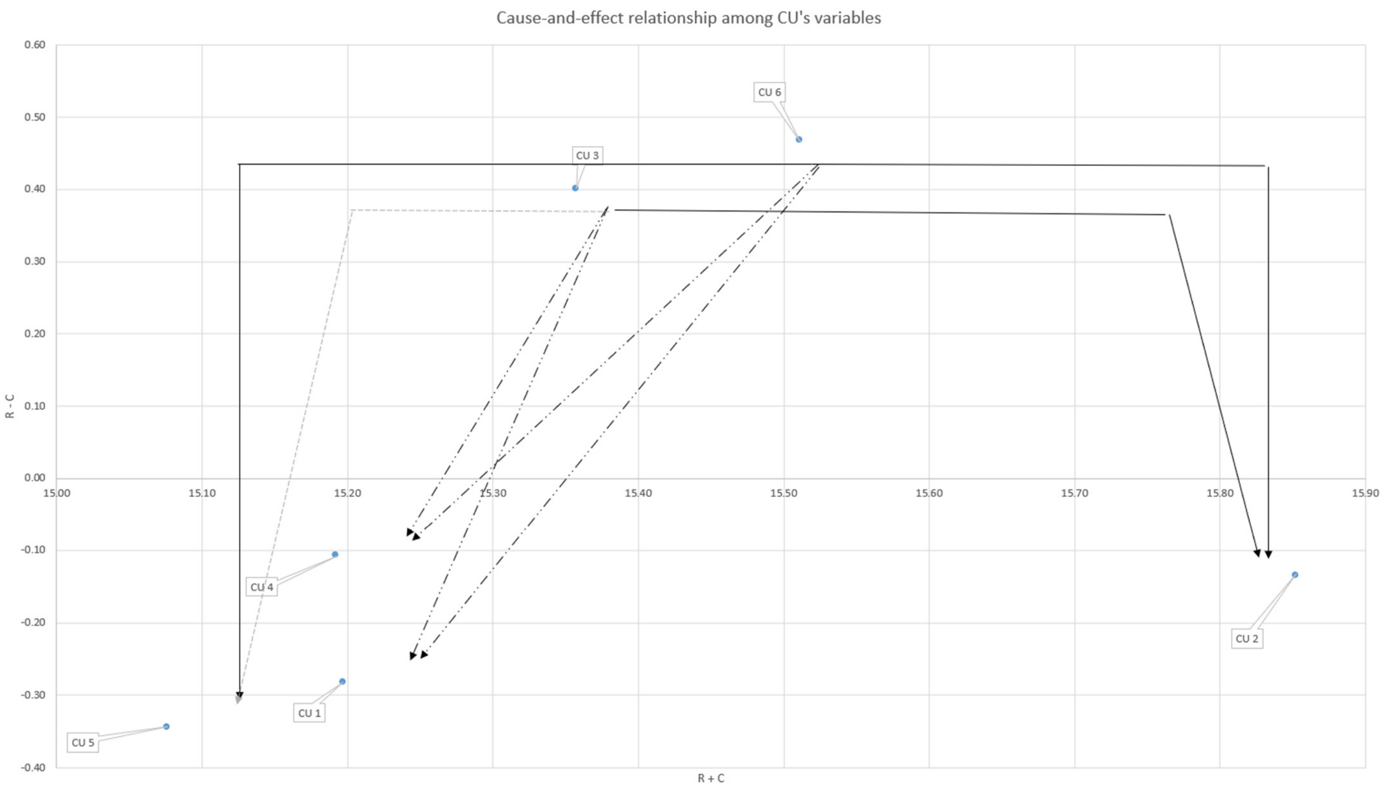

Figure 6. Impact–relation map of cultural dimension.

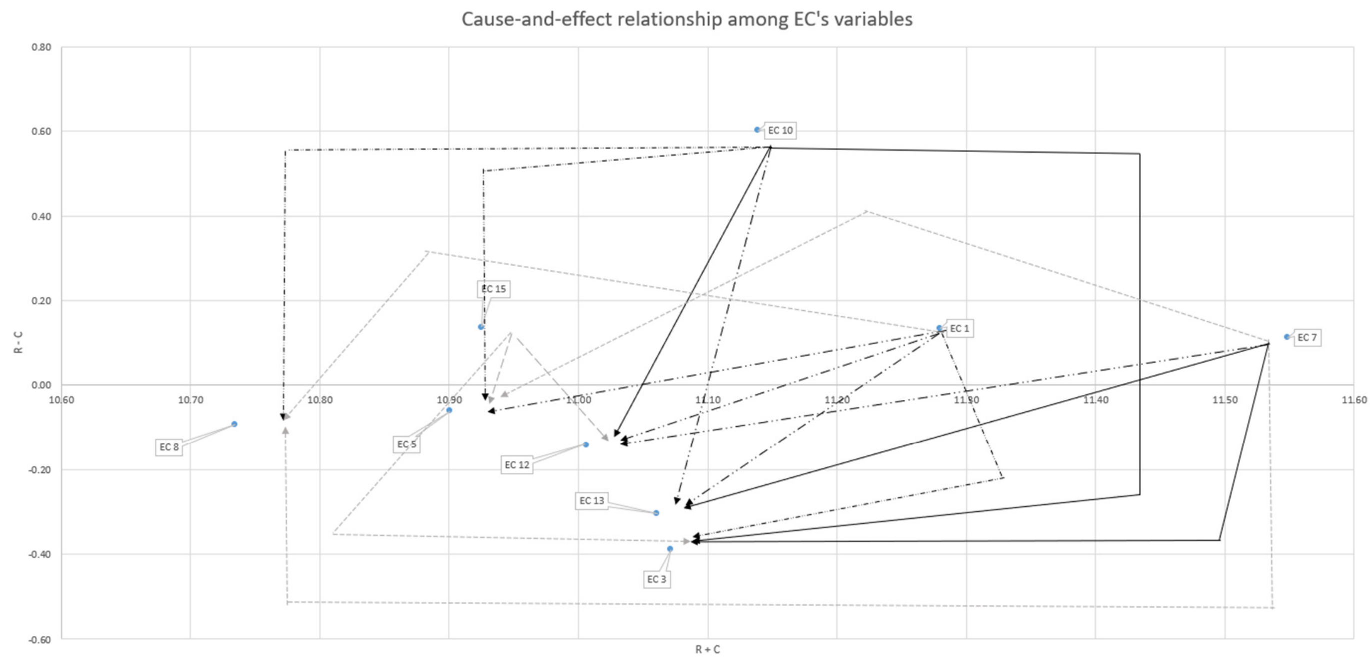

Figure 7. Impact–relation map of economic dimension.

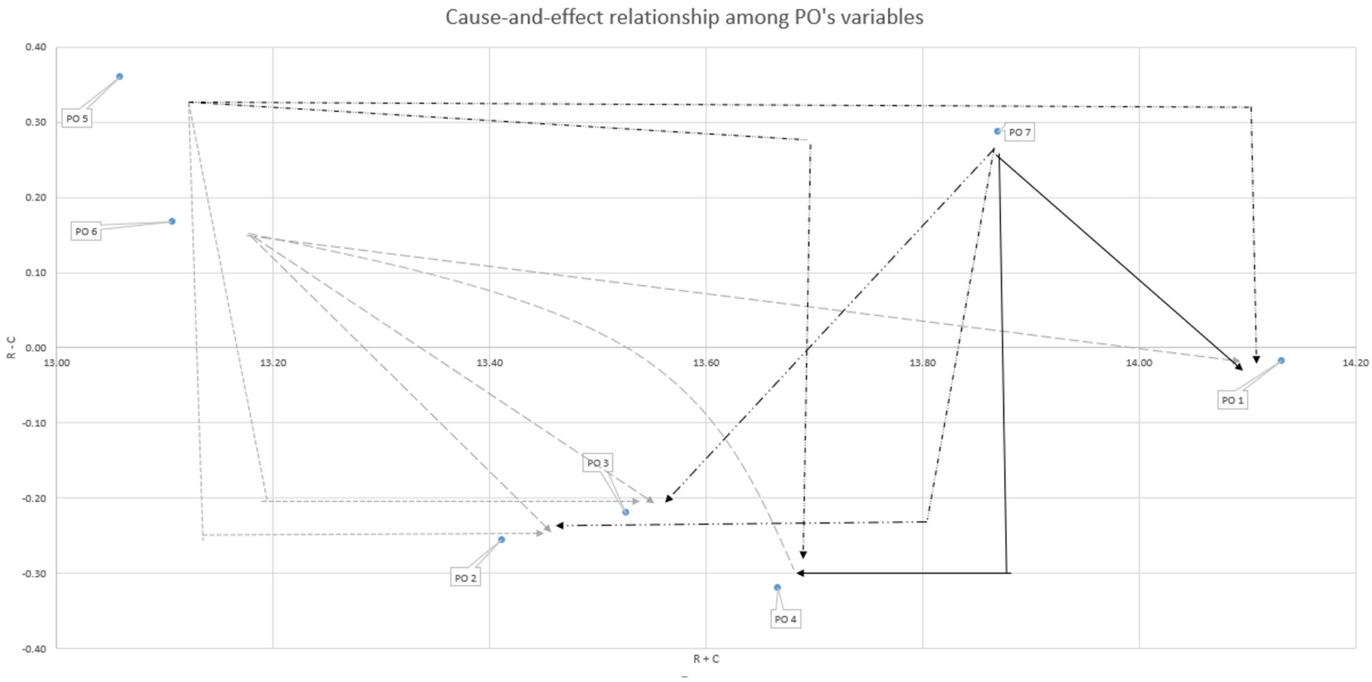

Figure 8. Impact–relation map of political dimension.

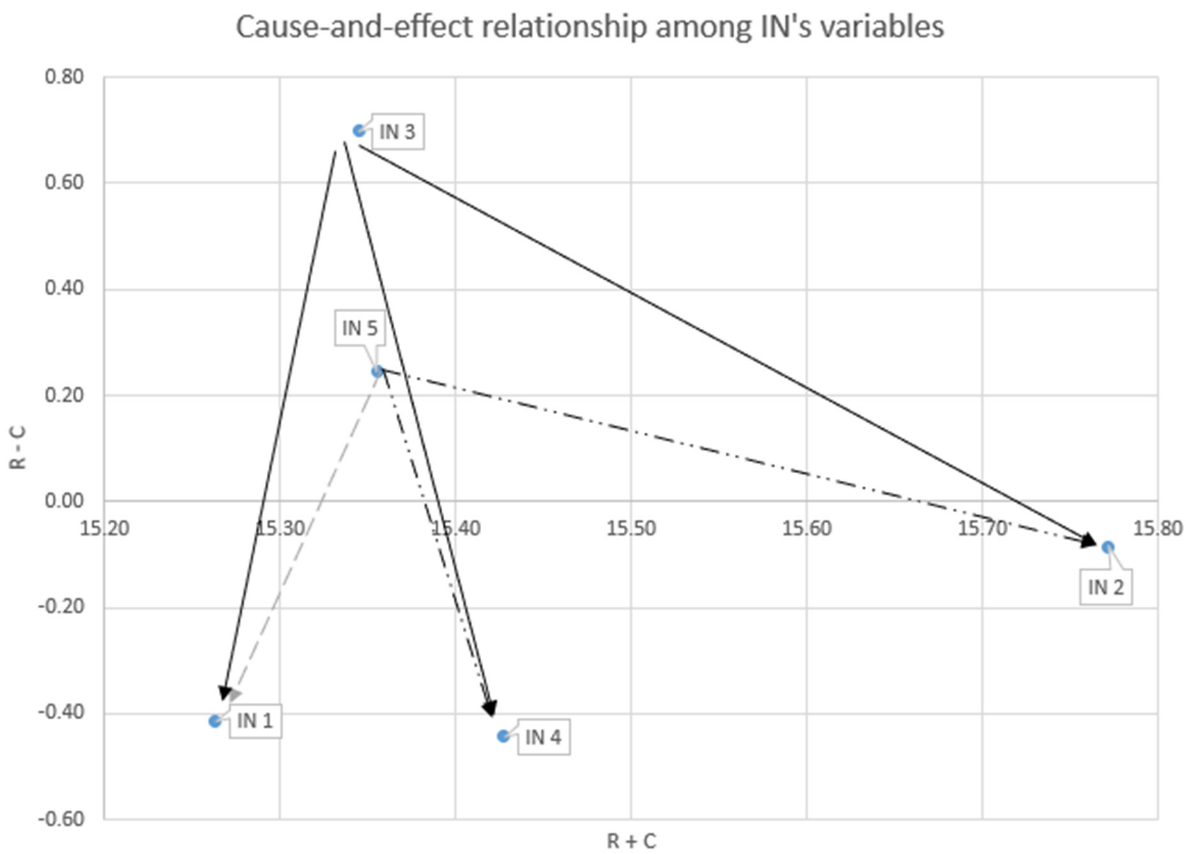

Figure 9. Impact–relation map of intrinsic dimension.

Regarding the environmental dimension in Figure 4, the group of EN variables is unique in that only EN13 was identified as a cause factor, and most of the time the relationship between cause factors and effect factors in this group is relatively weak. The impact of EN13 on EN1 has medium influence; the rest have weak influence.

Regarding the social dimension in Figure 5, this is the most complicated group of variables for the SO variable group. There are five factors that are said to be cause factors and six factors that are said to be effect factors. Among the cause variables, SO5 has the highest position as well as having the most "strong influence" curves, which means that SO5 has the most significant impact on the effect factors. In contrast, among the effect variables, SO13 is the variable most affected by the cause factors.

With respect to the cultural dimension in Figure 6, for the group of CU variables, there are two variables (CU3 and CU6) that are considered as cause factors while the remaining four are effect factors. Similar to the argument regarding SO, CU6 has the most substantial impact on the effect factors and CU2 is the most affected by the cause factors.

Regarding the economic dimension (Figure 7), political dimension (Figure 8), and intrinsic dimension (Figure 9), similar comments can be made on these three remaining groups of variables. EC10, PO7, and IN3 are the cause factors that have the most decisive impact on the effect factors. In contrast, EC3, PO1, and IN2 are the most affected effect factors.

4.4. Discussion

In the existing literature review, numerous studies have explored the field of sustainable ecotourism using various quantitative and qualitative methodologies. For instance, studies have investigated the ecotourism suitability of Babol in Iran [71], the development of ecotourism in Thailand [72], and the site selection of ecotourism in Zhejiang province [73]. However, this study stands out due to its unique integration of the Fuzzy Delphi and Fuzzy DEMATEL approaches, which has not been previously attempted. By utilizing this integrated methodology, we are able to effectively identify and analyze the key variables in sustainable ecotourism, thereby gaining a comprehensive understanding of their interrelationships. This knowledge is invaluable for prioritizing and implementing initiatives or interventions that promote the long-term developmentw of ecotourism in Belize. The findings of this research contribute significantly to the existing body of knowledge and provide practical insights for sustainable ecotourism management in the region.

The findings of our study support the notion that all six dimensions—environmental, social, cultural, economic, political, and intrinsic—serve as qualified indicators for evaluating sustainable ecotourism, which aligns with previous research in this field. Previous studies have also emphasized the significance of considering multiple dimensions when assessing sustainable tourism practices. For instance, Carpio et al. [74] identified several dimensions—environmental, economic, social, and institutional—as important indicators of sustainable tourism. Similarly, Janusz et al. [27] acknowledged three dimensions—economic, environmental, and social—as crucial for evaluating sustainable tourism.

The application of the Fuzzy DEMATEL method in our study allowed us to investigate the cause/effect relationships among the six dimensions of sustainable ecotourism. Our findings reveal that the environmental, cultural, economic, and intrinsic dimensions serve as net causes of sustainable ecotourism, indicating that they have a direct positive impact on other dimensions. Conversely, the political and social dimensions emerge as net effects of sustainable ecotourism, suggesting that they are influenced more by the other dimensions. Specifically, our results highlight the strong influence of the intrinsic and economic dimensions on the political dimension. The intrinsic factors, encompassing personal growth and spiritual well-being, may shape the values and attitudes of policymakers, leading to their support for sustainable practices. Likewise, economic factors such as local economic benefits and resource efficiency can incentivize policymakers to prioritize sustainability in tourism development. This finding aligns with previous research that emphasizes the importance of stakeholder engagement and participation in fostering sustainable tourism [75,76]. Additionally, our findings underscore the significance of the cultural dimension as a net cause of sustainable ecotourism. This emphasizes the importance of preserving local heritage, promoting cultural authenticity, and involving local communities in ecotourism development [77].

Overall, our findings reveal the complex interplay among the different dimensions of sustainable ecotourism and emphasize the need for a multidimensional approach to sustainable tourism development. Policies and practices that prioritize the environmental, cultural, economic, and intrinsic dimensions, while considering their impact on other dimensions, are likely to be the most effective in promoting sustainable ecotourism. By understanding these cause/effect relationships, policymakers and stakeholders can make informed decisions and implement strategies that address the interconnected nature of sustainable tourism and contribute to the long-term well-being of both the environment and local communities.

In this study, the inclusion of environmental indicators in the assessment of sustainable ecotourism provides a comprehensive framework for evaluating the impact of tourism on the environment. Our findings, which align with a previous study in Belize [78], suggest that EN2, EN5, and EN8 may be crucial in assessing the environmental impact of sustainable ecotourism. Furthermore, the results reveal that among the environmental indicators, only EN13 (recovery and mitigation of tourism damage) serves as a net cause, while the other indicators act as net effects. This implies that focusing on the restoration and reduction of tourism damage can have a positive influence on other environmental indicators. Therefore, it is crucial to prioritize recovery efforts and minimize the negative impacts caused by tourism activities in order to enhance the overall environmental sustainability of ecotourism. This finding is consistent with the study on local people's perceptions of ecotourism in Belize conducted by Holladay et al. [79].

The results of the Fuzzy Delphi process show that the social aspect of sustainable ecotourism can be assessed using 11 indicators: SO3, SO4, SO5, SO6, SO7, SO8, SO9, SO10, SO12, SO13, and SO14. SO1, SO2, and SO11 were eliminated based on expert assessment and consensus in the Fuzzy Delphi process. One possible reason SO1 was dropped is that it may not be considered an essential issue in the particular context of the study. In addition, disability law may be seen as a legal obligation rather than a social responsibility of the tourism industry in some regions, which may explain why it was dropped. SO2 was likely eliminated because it overlaps with other indicators such as fair treatment, compliance with labor laws, and protection of minorities. Finally, SO11 may have been dropped due to the difficulty of quantifying and measuring the extent to which minority groups are protected.

These results indicate that the cultural dimension of sustainable ecotourism is mainly influenced by the promotion and protection of local culture (CU6) and cultural codes of conduct for tourists (CU3), which have substantial effects on the availability and accessibility of information about local culture (CU2). According to Lonely Planet, the cultural legacy of Belize is closely connected to its natural surroundings [80]. Tourists have the opportunity to participate in genuine cultural activities, such as acquiring knowledge about ancient Maya agricultural methods, joining a drumming workshop conducted by the Garifuna community, or getting to know the Kriol culture in Gales Point Manatee village. This implies that well-informed tourists are more likely to respect and appreciate local cultures and have clear guidelines for interacting with local communities. Additionally, CU6 strongly affects the adverse effects of development projects on cultural identities (CU5), suggesting that protecting and promoting local culture can mitigate the potential negative impacts of tourism-related development on cultural heritage. Therefore, ecotourism stakeholders need to prioritize promoting and protecting local culture and establish clear guidelines for cultural interaction and respect to ensure the sustainability of the cultural dimension of ecotourism.

After the Fuzzy Delphi process, six metrics, namely EC2, EC4, EC6, EC9, EC11, and EC14, were removed for various reasons, but mainly because these variables are small factors that can be included in other variables; for example, EC2 can be included under EC12 and EC4 can be included under EC1 or EC7. The results of the Fuzzy DEMATEL analysis in this respect show that EC10, a measure of risk management and production stability, has a substantial impact on both EC3 and EC12. EC3 refers to keeping the local economy up to speed, while EC12 refers to measures to support and contribute to developing local goods, services, and infrastructure. This suggests that effective risk management and production stabilization can help sustain the local economy by promoting the growth of local goods and services while maintaining a steady economic pace. This is also mentioned in *Tourism, Local Economic Development, and Poverty* [81] and the book titled *Regional Economic Development* [82]. In addition, the analysis suggests that EC7, which measures employment opportunities, financial subsidies, and compensation to local people, significantly affects both EC3 and EC13. This suggests that supporting local employment and providing reasonable compensation and financial assistance can contribute to sustaining the local economy's growth while promoting entrepreneurs' development as local suppliers and manufacturers. These results suggest that the sustainable tourism industry should prioritize effective risk management and support local employment to promote conservation and economic development.

Through Fuzzy Delphi, no variable in the PO dimension is excluded. This proves that experts agree that all variables are significant for sustainable ecotourism. In addition, the Fuzzy DEMATEL results show that PO7, which measures the reflection of sustainability values on business operations, significantly impacts PO4, which measures ethical organizational structures, ethics, and transparency, and PO1, which measures external organizational structures involved in and owning local businesses. PO7 is also considered the cause factor with the most significant impact on the effect factor in this dimension. In contrast, PO4 is the effect factor most affected by the cause factor. The results suggest that focusing on sustainable values in the tourism industry can help promote an ethical and transparent organizational structure while reducing the negative impact of participation and foreign ownership on local businesses.

Like the PO dimension, the IN dimension also had no variable removed using Fuzzy Delphi. The results of the Fuzzy DEMATEL method indicate that IN3 has a significant impact on IN1, IN2, and IN4, indicating that safety and security are essential factors affecting the intrinsic aspect of sustainable tourism. Tourists prioritize safety and security when choosing a travel destination, and these factors directly affect tourists' overall satisfaction. Therefore, IN3 (crime, accident rate, and visitor safety and security) affects IN1 (local people's attitude towards satisfaction, service quality, and training mechanisms), IN2 (average duration of stay per visitor), and IN4 (overall service quality of local businesses and potential businesses), as they all have a relationship.

5. Conclusions, Implications, Limitations and Future Work

5.1. Conclusions

In this study, we make significant contributions to the field of sustainable tourism performance evaluation. The authors have developed a comprehensive framework consisting of six dimensions and 63 indicators, which provides a holistic approach to assessing the sustainability of tourism activities. The framework was developed through a rigorous process that involved expert consultation using the Fuzzy Delphi method, ensuring that the most critical aspects of sustainable tourism were captured. Our findings confirm our hypothesis regarding the importance of different dimensions in sustainable tourism performance. The environmental dimension emerged as the most critical dimension, highlighting the significance of environmental preservation and minimizing the negative impact of tourism activities. This was followed by the economic, social, cultural, and political dimensions, all of which play essential roles in sustainable tourism development. To further explore the interrelationships between these dimensions, we conducted an analysis using the Fuzzy DEMATEL method. This analysis revealed several indicators that exerted a strong influence on other indicators within the framework. Identifying these influential indicators is crucial for prioritizing efforts and resources in sustainable tourism development. To summarize, this study emphasizes the need for a multidimensional and integrated approach to sustainable tourism performance evaluation. By considering the environmental, economic, social, cultural, and political dimensions, policymakers, managers, and stakeholders can gain a comprehensive understanding of the sustainability of tourism activities and make informed decisions to enhance sustainability.

5.2. Theoretical Implications

The theoretical implications of this study are of significant importance to both academics and practitioners in the field of sustainable ecotourism, not only in Belize but also in the broader travel and tourism sector. This study contributes to the theoretical understanding of sustainable ecotourism in the following ways: Firstly, this study identifies and emphasizes six crucial dimensions—environmental, social, cultural, economic, political, and intrinsic factors—which have a direct impact on sustainable ecotourism. By focusing on these key areas, sustainable development efforts can be more targeted and effective, addressing the specific challenges and opportunities within the realm of sustainable ecotourism. This framework provides a comprehensive understanding of the multifaceted nature of sustainable ecotourism, enabling stakeholders to develop strategies and policies that align with these dimensions. Secondly, this study reinforces the significance of specific factors that contribute to sustainable ecotourism, such as the restoration and reduction of damage caused by tourism (EN13), the improvement of the well-being, quality of life, and safety of the local community (SO5), and the promotion and protection of local culture (CU6). While previous studies have recognized the importance of these factors, this study provides additional evidence and reaffirms their critical role in the ecotourism industry. These findings serve as a valuable reference for future research and can guide practitioners in implementing measures to enhance sustainable business growth. Lastly, this study uncovers the causal relationships between the variables within each dimension, offering insights into the underlying mechanisms and interdependencies that shape sustainable ecotourism. By understanding these causal connections, stakeholders can identify areas for improvement, identify root causes of issues, and develop effective interventions to address any existing shortcomings. This knowledge empowers decision makers to prioritize their efforts and allocate resources efficiently, fostering the long-term sustainability of ecotourism initiatives.

5.3. Managerial Implications

The conclusions drawn from this study have important managerial implications for the tourism industry. Managers and policymakers should focus on four key aspects—economy (EC), intrinsic dimension (IN), environment (EN), and culture (CU)—as they are considered crucial cause factors for the development and improvement of ecotourism. Firstly, in terms of the economic dimension, authorities need to prioritize job opportunities and implement favorable financial policies for the local communities in tourism-exploited areas. Additionally, effective risk management and production stabilization measures should be implemented. Attracting investment resources is also vital in enhancing the overall quality of the tourism industry and attracting more visitors. Secondly, in the intrinsic dimension, special attention should be given to tourist satisfaction with related activities and the volume of tourists, including returning visitors and seasonality. Meeting tourists' needs and providing valuable experiences are key factors in determining whether they will return to a destination. It is also important to address crime rates, visitor safety, and security concerns to ensure a safe and secure environment for tourists. Thirdly, in the environmental dimension, this study emphasizes the importance of the restoration and reduction of damage caused by tourism. Policies and practical actions aimed at recovering and mitigating the negative impacts of tourism are essential for sustainable ecotourism. These efforts help preserve the unique characteristics of the destination, differentiating it from other places and serving as a decisive factor in attracting tourists. Lastly, the findings related to the cultural dimension highlight two key factors that require attention: cultural codes of conduct for tourists and the promotion and protection of local culture. Emphasizing and showcasing the cultural heritage of the area can be an effective strategy to attract tourists and promote sustainable ecotourism. Encouraging visitors to learn about and respect local culture and traditions is crucial in preserving cultural identities and fostering a positive cultural exchange between tourists and local communities.

5.4. Limitations and Future Work

The limitations of this study should be acknowledged to provide a clearer understanding of the study's scope and potential areas for improvement. Firstly, the framework developed in this study was focused on sustainable tourism in Belize, and its applicability to other regions or countries may require further examination. Future research should aim to validate and refine the framework in different geographical contexts to enhance its generalizability and ensure its effectiveness in diverse settings. Secondly, although the framework included a comprehensive set of dimensions and indicators, there may be additional factors that were not considered in this study. Future research could explore the inclusion of other dimensions, such as technological advancements, governance structures, or community engagement, which may play significant roles in sustainable tourism performance. Another limitation is that the data used in this study relied on expert consultation and may be subjective to some extent. Future research could incorporate primary data collection from various stakeholders, including tourists, local communities, and industry practitioners, to provide a more comprehensive and objective assessment of sustainable tourism performance. Furthermore, the analysis in this study focused on identifying causal relationships between dimensions using the Fuzzy DEMATEL method. Future research could expand on this by conducting quantitative analyses, such as structural equation modeling or regression analysis, to examine the complex interplay between dimensions and their impact on overall sustainable tourism performance. Additionally, while the defuzzification procedure used in this study facilitated the interpretation and analysis of cause/effect relationships, it may not capture the full complexity of fuzzy algebra rules. Exploring the application of fuzzy algebra rules for determining cause/effect relationships could be a valuable extension in future research. Moreover, this study primarily focused on the evaluation of sustainable tourism performance rather than providing detailed strategies or interventions for improvement. Future research could delve deeper into developing specific management strategies, policies, and best practices based on the findings of this study, to guide practitioners and policymakers in implementing sustainable tourism initiatives effectively. Lastly, the temporal aspect of sustainable tourism was not explicitly addressed in this study. Future research could explore the dynamics of sustainable tourism performance over time and investigate the long-term impacts of various interventions and policies on sustainability outcomes. By recognizing and addressing these limitations, future research can build upon the findings of this study and contribute to the advancement of knowledge in the field of sustainable tourism, ultimately leading to more effective and impactful practices and policies.

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