

TOWARDS SUSTAINABLE TOURISM: DESIGNING A SUSTAINABLE SUPPLY CHAIN STRATEGY FOR THE TOURISM INDUSTRY THROUGH THE INTEGRATION OF FUZZY AHP AND PLS-SEM

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Abstrak:

This study examines the implementation strategy of Sustainable Supply Chain Management (SSCM) in the tourism industry by integrating economic, social, environmental, and institutional dimensions. The research aims to formulate data-driven strategic priorities. A quantitative approach using SEM-PLS was employed to analyze causal relationships, and a Fuzzy AHP was used to rank sustainability priorities. Results indicate that environmental, social, and institutional sustainability positively affect SSCM, whereas economic sustainability negatively influences it. Fuzzy AHP ranks environmental sustainability as the top priority. The findings highlight the need for policy alignment, community involvement, and business commitment to build competitive and sustainable tourism destinations.

Keyword: Sustainable Development; Sustainable Tourism; Supply Chain management; Tourism Supply Chain; Sustainable Supply Chain Management;

INTRODUCTION

The tourism industry occupies a critical juncture between economic advancement and environmental sustainability. In recent decades, it has emerged as a key engine of economic growth, stimulating job creation, attracting investment, and boosting national income (Cárdenas-García & Alcalá-Ordóñez, 2023). In the Indonesian context, the tourism sector plays a strategic role not only in contributing to gross domestic product but also in supporting the nation's broader sustainable development agenda. This aligns with Asta Cita's vision, which emphasizes harmonizing industrial progress with environmental preservation.

Alcalá-Ordóñez et al. (2024) highlight the positive contribution of tourism to

economic development in island countries, where a reciprocal causal relationship has been identified. Nonetheless, the expansion of tourism activities is frequently accompanied by increased energy demand and higher greenhouse gas emissions (Irfan et al., 2023). Although tourism has the potential to drive economic progress, its long-term success depends on achieving a sustainable equilibrium between growth and environmental preservation and ensuring active participation from all relevant stakeholders (Cárdenas-García & Alcalá-Ordóñez, 2023). Without implementing a sustainable supply chain framework, the continued growth of the tourism industry may undermine environmental resilience and jeopardize the sector's long-term sustainability.

Sustainable Supply Chain Management (SSCM) has gained prominence as a strategic approach to addressing sustainability-related challenges, focusing on integrating sustainability principles across all stages of the tourism supply chain. These practices are increasingly recognized for their critical role in harmonizing economic development with environmental stewardship and social accountability (Ali et al., 2024). Qorri et al. (2020) highlight a positive correlation between SSCM practices and social, operational, economic, and environmental performance. Furthermore, Shekarian et al. (2022) identify key categories and practices within SSCM as critical components for achieving sustainability across its three dimensions: economic, social, and environmental.

The implementation of SSCM is influenced by a range of internal and external drivers, with regulatory frameworks and market expectations emerging as the most influential factors (Sajjad et al., 2020). Within the tourism industry, adopting SSCM is vital to achieving long-term sustainability by mitigating adverse environmental, social, and economic consequences across the supply chain (Oyedijo et al., 2024; Thahir et al., 2022). SSCM also encompasses social considerations, including the enforcement of human rights and equitable labor practices, alongside economic aspects such as employment generation and fair distribution of economic gains, thereby reinforcing the sector's overall sustainability. However, Wardana et al. (2024) note that, despite growing awareness and regulatory interventions, many tourism destinations still face significant challenges in implementing supply chain strategies that yield meaningful and effective outcomes.

The tourism industry's supply chain involves complex interactions among stakeholders with diverse and sometimes competing interests. This complexity involves various actors, including local suppliers and tour operators, accommodation providers, local governments, and community groups. These parties are mutually dependent, and suboptimal coordination may negatively affect service quality, environmental preservation, and tourists' perceptions of the destination. In Indonesia, only 22 percent of tourism businesses have adopted green practices in a holistic manner, indicating that the implementation of SSCM remains largely partial and fragmented (Wardana et al., 2024). This outcome highlights the critical need for a holistic and cohesive approach to SSCM implementation within Indonesia's tourism sector.

Moreover, the *Asta Cita* national development agenda emphasizes the need to maintain equilibrium across the economic, social, and environmental pillars. In response, this study advocates for the design of an empirically driven SSCM strategy. First, the strategy should integrate the entire supply chain, including suppliers, operators, and local communities. Second, it should map the trade-offs between economic growth and environmental carrying capacity. Third, it should address the specific needs of the green economy in local areas, such as Lampung, where rapid development of tourism infrastructure has contributed to the degradation of mangrove ecosystems. The green economy concept emphasizes efficient resource management and low-carbon development, while the blue economy focuses on the preservation of coastal and marine ecosystems, including mangroves, coral reefs, and traditional fisheries, in order to support the

sustainability of local economies in coastal regions.

Without a structured approach, Indonesia's ambition to become one of the world's top ten sustainable tourism destinations by 2045 is at risk of not being realized. In addition to internal business factors and market pressures, national policies such as *Sapta Pesona*, the 2025–2045 National Medium-Term Development Plan, and regional regulations also play a critical role in promoting the implementation of SSCM. However, weak law enforcement and inconsistent policy execution often present major challenges at the destination level.

Accordingly, this study seeks to address the challenge of formulating an optimal strategy for implementing SSCM in the tourism industry, while accounting for the intricate nature of supply chain configurations and the multitude of factors affecting sustainability. The primary aim is to identify and evaluate the most effective approaches for applying SSCM practices within the tourism context.

Data from BEKRAF (2023) indicate that among Indonesia's many tourist destinations, only 19 are classified as high-quality, sustainable destinations. This stands in contrast to a survey conducted by Booking.com (2020), which found that 93 percent of Indonesian travelers consider sustainable tourism to be important, and 72 percent express a commitment to choosing sustainable options when traveling in the future.

At present, the implementation of SSCM in the tourism industry is showing a positive trend. However, its application remains sporadic and lacks a well-structured framework. According to the Ministry of Environment and Forestry (2023), 68 percent of priority destinations are facing ecological stress due to excessive exploitation. On the other hand, only 45

percent of local communities are actively involved in the tourism value chain (Bachtiar, 2022), reflecting limited participation in management and in the distribution of economic benefits. This lack of community involvement may contribute to unequal benefit distribution, social conflict, and the erosion of local cultural values, which should otherwise serve as key attractions in tourism development.

Therefore, SSCM strategies must emphasize community empowerment to achieve social equity. This underscores the urgency of conducting research that can identify effective strategies for implementing sustainability in tourism operations without compromising the balance between economic, social, and environmental dimensions. In addition, this research aligns with the national development priorities articulated in the *Asta Cita* framework, particularly by advancing the green and blue economy agendas, fostering regional economic inclusivity, and upholding a balanced integration of economic expansion, environmental protection, and cultural heritage preservation within the tourism sector (Indonesia portal information, 2024).

RESEARCH METHOD

This study employs a quantitative approach combining the Analytic Hierarchy Process-Fuzzy (AHP-Fuzzy) and Structural Equation Modeling-Partial Least Squares (SEM-PLS). Xhafaj et al. (2022) previously integrated PLS-SEM, AHP, and FAHP to evaluate factors influencing the use of learning management systems. In addition, Qendraj et al. (2022) proposed a framework that combines PLS-SEM with Fuzzy Z-AHP to assess the UTAUT2 model in learning management systems. Similarly, Asadollahi et al. (2021)

developed a new composite model by combining SEM and AHP for supplier selection.

Thus far, no prior research has integrated both AHP-Fuzzy and SEM-PLS methodologies in the context of the tourism sector. This methodological integration constitutes a key novelty of the current study. The combined approach is designed to uncover the critical factors affecting the sustainability of the tourism supply chain and to formulate the most effective strategies for implementing SSCM.

Data were gathered using a quantitative survey approach by distributing a structured questionnaire to practitioners, stakeholders, and academics in the tourism industry. A stratified sampling method was employed, dividing the population into distinct homogeneous groups, including Community-Based Tourism (CBT) organizations, Kelompok

Sadar Wisata (PokDarWis), destination managers, tourists, and government officials. A proportional sample consisting of 100 respondents was selected for analysis.

In the initial phase of data analysis, the Partial Least Squares Structural Equation Modeling (PLS-SEM) technique was employed to evaluate the conceptual model, which includes the economic, social, environmental, and institutional dimensions. This analysis produced path coefficients, loading factors, R-square and Q-square values, and hypothesis testing via bootstrapping. Subsequently, the Fuzzy-AHP analysis was conducted to determine strategic priorities by developing a hierarchical structure, constructing pairwise comparison matrices, and calculating priority weights, followed by consistency testing.

Table 1. Operational definition of research variables

Variabel	Code	Indikator	Reference
ECONOMIC SUSTAINABILITY (KE)	KE1	Increased local income	(Kuba et al., 2024; Li et al., 2022; Vapa-Tankosić et al., 2020)
	KE2	Operational cost efficiency	
	KE3	Employment absorption	
	KE4	Income diversification	
	KE5	Economic competitiveness	
SOCIAL SUSTAINABILITY (KS)	KS1	Community involvement	(Santos, 2023; Vargas-Sanchez, 2022)
	KS2	Social awareness	
	KS3	Quality of life	
	KS4	Worker protection	
	KS5	Cultural preservation	
ENVIRONMENTAL SUSTAINABILITY (KL)	KL1	Fossil fuel reduction	(Abul et al., 2024; Bentley, 2024; Papakonstantinou, 2024)
	KL2	Waste management	
	KL3	Ecosystem preservation	
	KL4	Environmentally friendly materials	
	KL5	Environmental education	

INSTITUTIONS AND REGULATIONS (KR)	KR1	Government policy	(Asadollahi et al., 2021; Samoilenko, 2024)
	KR2	Technical regulations	
	KR3	Fiscal incentives	
	KR4	Cross-sector synergy	
	KR5	Legal oversight	
IMPLEMENTATION SSCM (IS)	IS1	Integration of environmentally friendly practices	(Alcalá-Ordóñez et al., 2024; Sajjad et al., 2020)
	IS2	Collaboration with local suppliers	
	IS3	Environmental performance monitoring	
	IS4	Use of green technology	
	IS5	Sustainability reporting	
TOURISM DESTINATION PERFORMANCE (KD)	KD1	Tourist satisfaction levels	(Chiesa & Przychodzen, 2020; Rahmayani et al., 2022)
	KD2	Number of tourist visits	
	KD3	Local revenue from tourism	
	KD4	Destination reputation	
	KD5	Strengthening of the local economy	

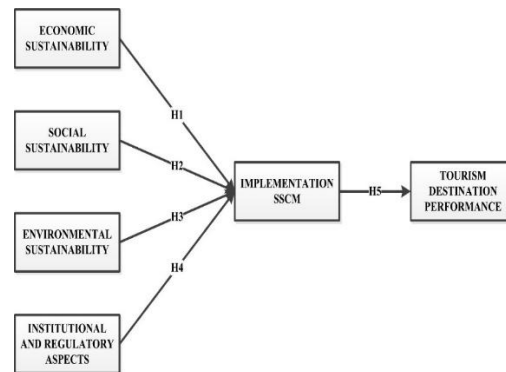


Figure 1. Hypothesis of the research



Figure 2. Fuzzy-AHP Hierarchy

RESULT

Sem-Pls (Validity and Reability Test)

To assess the adequacy of the measurement model, a comprehensive evaluation of validity and reliability was conducted. Convergent validity was examined to ensure that each indicator appropriately reflected its associated construct, while discriminant validity was assessed to confirm that the constructs were empirically distinct from one another. These validations were carried out using established statistical criteria, including outer loadings, average variance

extracted (AVE), and inter-construct comparisons.

In parallel, reliability testing aimed to evaluate the internal consistency of the measurement instruments. This involved analyzing composite reliability, Cronbach's alpha, and alternative reliability coefficients. The outcomes of these assessments confirm that the constructs used in this study possess sufficient validity and reliability, and are therefore appropriate for continued analysis within the structural model framework.

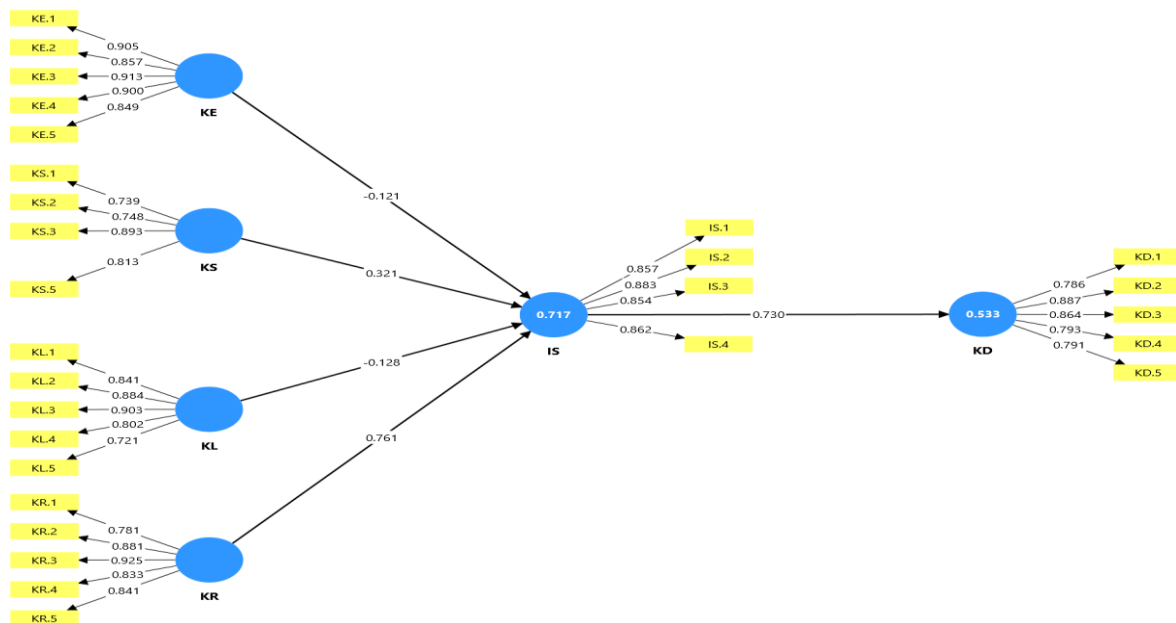


Figure 3. Outer loadings

Table 2. Convergent Validity

Fornell-Larcker criterion						
	IS	KD	KE	KL	KR	KS
IS	0.864					
KD	0.730	0.825				
KE	0.247	0.345	0.885			
KL	0.449	0.388	0.181	0.833		
KR	0.806	0.634	0.310	0.623	0.854	
KS	0.596	0.536	0.486	0.392	0.506	0.800
Heterotrait-monotrait ratio (HTMT) - Matrix						
	IS	KD	KE	KL	KR	KS
IS						
KD	0.816					
KE	0.266	0.379				
KL	0.497	0.428	0.197			
KR	0.890	0.697	0.326	0.696		
KS	0.695	0.626	0.551	0.435	0.587	

Source: Primary Data Processed, 2025

Table 3. Reability Test

	Cronbach's alpha	rho_a	Composite reliability	Average variance extracted (AVE)
IS	0.887	0.889	0.922	0.746
KD	0.883	0.891	0.914	0.681
KE	0.932	0.952	0.948	0.784
KL	0.888	0.899	0.918	0.694
KR	0.906	0.914	0.931	0.729
KS	0.812	0.829	0.876	0.641

Source: Primary Data Processed, 2025

Hypothesis test

Hypothesis testing in this study was conducted by analyzing the coefficient values for each path, including direct, indirect, and total effects. The testing process employed the t-test by comparing the obtained probability value (p-value)

with the predetermined significance level ($\alpha = 0.05$). If the p-value is less than 0.05, the effect is considered statistically significant, and the proposed hypothesis is accepted. This approach enables the identification of the extent to which each variable contributes to other variables.

Table 4. Results of Hypothesis Test

	Original sample (O)	Sample mean (M)	Standard deviation (STDEV)	T statistics (O/STDEV)	P values
IS -> KD	0.730	0.732	0.051	14.374	0.000
KE -> IS	-0.121	-0.115	0.054	2.245	0.025
KL -> IS	0.128	-0.122	0.062	2.061	0.039

KR -> IS	0.761	0.752	0.106	7.149	0.000
KS -> IS	0.321	0.328	0.114	2.814	0.005

Source: Primary Data Processed, 2025

Fuzzy Analytical Hierarchy Process (Fuzzy-AHP)

This section outlines the use of the Fuzzy Analytical Hierarchy Process (Fuzzy AHP) to establish strategic priorities for implementing SSCM in the tourism sector. This method was selected to address the inherent subjectivity and ambiguity in expert evaluations by translating qualitative linguistic inputs into quantitative values based on fuzzy logic principles. Utilizing a structured multi-criteria decision-making framework, the analysis seeks to identify the most important sustainability dimensions and sub-dimensions as perceived by key stakeholders. The subsequent steps detail the procedures for constructing pairwise comparison matrices, computing fuzzy weights, and determining the final ranking of priorities.

Construction of the Comparison Matrix and Conversion of Linguistic Values into Triangular Fuzzy Numbers

The first step in the Fuzzy AHP analysis involves developing a pairwise comparison matrix based on evaluations provided by four groups of experts, including Community-Based Tourism (CBT) and PokDarwis members, tourism destination managers, tourists, and representatives from government institutions. These assessments aim to evaluate the relative importance of criteria and sub-criteria in determining priority strategies for SSCM in Lampung Province. Each expert provides input using linguistic scales such as "equally important," "more important," or "very important," which are then converted into numerical form through the

Triangular Fuzzy Number (TFN) approach. This conversion of linguistic values into fuzzy values (L, M, U) captures the uncertainty and imprecision inherent in the subjective judgments of the experts, allowing their perceptions to be represented more flexibly and realistically. The resulting fuzzy matrix from this conversion serves as the primary foundation for subsequent stages, including aggregation, synthetic weight computation, and strategy prioritization. The following is the formula used to calculate the aggregated TFN, as proposed by Chang (1996).

$$l_{ij} = \min(l_{ij}^1, l_{ij}^2, \dots, l_{ij}^k)$$

$$m_{ij} = \left(\prod_{k=1}^K m_{ij}^k \right)^{\frac{1}{K}}$$

$$u_{ij} = \max(u_{ij}^1, u_{ij}^2, \dots, u_{ij}^k)$$

: l,m,u = value of fuzzy lower, middle, upper
k = number of experts

Synthetic fuzzy (synthetic extent)

Following the conversion of linguistic inputs into Triangular Fuzzy Numbers (TFNs), the next phase involves computing the fuzzy synthetic extent for each criterion and sub-criterion. This process is carried out by dividing each component of the TFN (L, M, U) for a given criterion by the corresponding total L, M, and U values across all criteria. The resulting fuzzy synthetic extent reflects the preliminary fuzzy weight assigned to each criterion and forms the foundation for determining the degree of possibility and the final priority weights. The formula used to compute the synthetic extent (Si) is adopted from Chang (1996):

$$S_i = \left(\sum_{j=1}^n M_{ij} \right) \otimes \left(\sum_{i=1}^n \sum_{j=1}^n M_{ij} \right)^{-1}$$

: M_{ij} = fuzzy comparison matrix

Degree of Possibility

After obtaining the fuzzy synthetic extent values for each criterion and sub-criterion, the subsequent step involves calculating the degree of possibility. This metric is used to assess the likelihood that one criterion or sub-criterion is more influential or preferable than another. The comparison is made between the fuzzy synthetic extents of each criterion, allowing for the estimation of more definitive relative weights. The minimum value derived from these comparisons serves as the initial weight, which is then normalized so that the total weight equals

one. Therefore, this stage is essential in generating objective and consistent priority weights. The formulas for the degree of possibility (Chang, 1996) and the final normalized weights (Mikhailov & Singh, 2006) are presented as follows:

$$V(S_i \geq S_j) = \begin{cases} 1 & \text{jika } m_i \geq m_j \\ 0 & \text{jika } l_j \geq u_i \\ \frac{l_j - u_i}{(m_i - u_i) - (m_j - l_j)} & \text{lainnya} \end{cases}$$

: S_i dan S_j are fuzzy synthetic extents of criteria i and j .
 m is the fuzzy middle value.

l is the lower bound value (lowest fuzzy value).

u is the upper bound value (highest fuzzy value).

$$W_i = \frac{d_i}{\sum_{i=1}^n d_i}$$

: d_i = minimum degree of possibility value (V) for each S_i

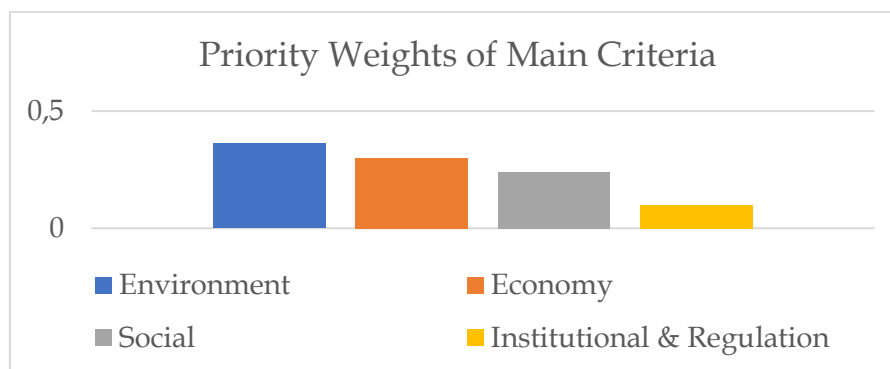


Figure 4. Priority Diagram of Main Criteria for Sustainable Tourism Supply Chain

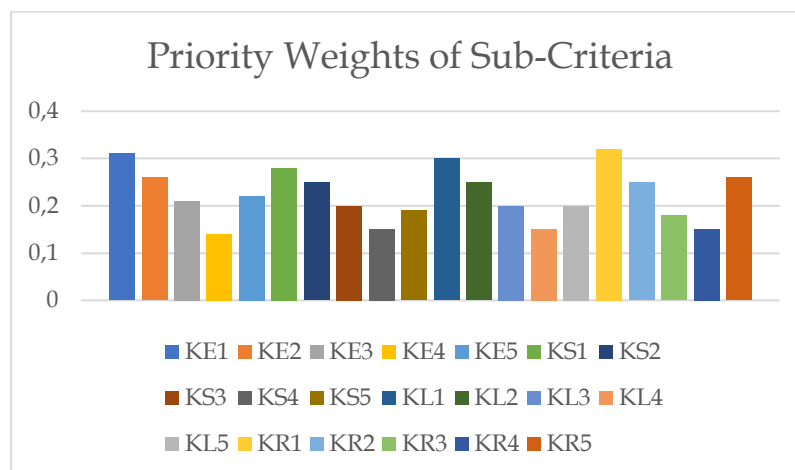


Figure 5. Priority Diagram of Sub-Criteria for Sustainable Tourism Supply Chain

DISCUSSION

The results of the analysis reveal that economic sustainability (KE) exerts a significant negative influence on the implementation of SSCM. This finding suggests that an excessive focus on short-term economic gains may hinder sustainability efforts within the supply chain. In practice, many tourism business actors prioritize rapid revenue growth, capacity expansion, and operational cost efficiency, which leads to the neglect of environmental and social investments. This pattern aligns with Qori'ah et al. (2020), who argue that dominant economic orientation may weaken commitment to sustainability. Moreover, the phenomenon of green hushing, defined as the tendency to conceal sustainability initiatives due to concerns over costs or regulatory burdens, reinforces this trend (Falchi et al., 2022).

In contrast, environmental sustainability (KL) demonstrates a significant positive effect on the implementation of SSCM. Environmental commitment motivates businesses to adopt sustainability principles more seriously across their supply chains. Increasing environmental awareness, driven by ecosystem degradation, pollution, and the loss of natural attractions, has led destination managers to implement programs such as reducing single-use plastics, using renewable energy, and conserving biodiversity. Wang et al. (2022) explain that environmental orientation strengthens the adoption of green innovations. Meanwhile, Qori'ah et al. (2020) highlight that a strong commitment to environmental sustainability is essential in establishing a destination's competitive reputation.

Institutional and regulatory factors (KR) also contribute significantly to the successful implementation of SSCM. This finding highlights the critical role of

formal policies and regulatory support in enhancing sustainable practices. Government incentives, eco-label certifications, waste management regulations, and routine monitoring can improve compliance and raise sustainability standards within the tourism industry (Armadi, 2021). Clear regulations help reduce market uncertainty, improve risk perception, and foster a more favorable climate for green investment.

Social sustainability (KS) likewise shows a significant effect on SSCM implementation. Local community participation, improved quality of life, and empowerment initiatives are essential to achieving long-term sustainability. Community-based approaches, such as developing cultural tourism packages, providing training for eco-friendly homestays, and strengthening tourism cooperatives, enhance public trust and foster a strong sense of ownership over sustainability programs. Dushkova and Ivlieva (2024) state that the success of sustainable programs largely depends on community support, while Ali et al. (2024) highlights the importance of social legitimacy in facilitating SSCM implementation.

The adoption of SSCM positively influences the performance of tourism destinations. The application of sustainability principles within the tourism supply chain improves destination reputation, tourist satisfaction, and economic achievements. Strategies such as utilizing local products, increasing energy efficiency, integrated waste management, and promoting sustainability values help maintain long-term attractiveness. Hendriksen (2023) states that sustainable practices enhance destinations' global competitiveness. López-Gamero et al. (2024) further

emphasize the tangible contributions of sustainability to the financial and social performance of destinations.

Overall, these results highlight the strong interconnection among economic, environmental, social, and institutional dimensions in influencing tourism destination performance through SSCM. SSCM not only enhances internal organizational performance but also serves as a strategic pathway toward long-term sustainable tourism development.

The Fuzzy AHP analysis provides additional insights by revealing the perceived strategic priority order among stakeholders. The environmental dimension ranks highest, followed by economic, social, and lastly institutional factors. This outcome is consistent with the growing awareness of environmental degradation, which encourages the tourism industry to prioritize ecologically based strategies (Thahir et al., 2022). The paradigm is shifting from a quantity-oriented model to one focused on quality and preservation. Prioritizing reductions in fossil fuels and waste management underscores the urgency of adopting low-carbon technologies and integrated waste systems. These strategies also align with the Sustainable Development Goals (SDGs).

Despite the dominance of environmental factors, economic dimensions remain vital, particularly in enhancing local community welfare by promoting more equitable benefit distribution. This supports the community-based tourism (CBT) approach, which places local communities at the forefront of destination management. The social dimension, which ranks third, reinforces the importance of active participation for successful sustainability policy implementation. Conversely, the institutional dimension's

low priority reflects persistent challenges in regulatory enforcement, including weak law enforcement and suboptimal industry incentives.

The contrast between SEM-PLS and Fuzzy AHP findings underscores the complementary nature of these two approaches. SEM-PLS reveals causal relationships influencing SSCM implementation, while Fuzzy AHP captures stakeholders' strategic perceptions and value priorities. Their integration enables the formulation of more targeted sustainability strategies, both in policy and in practical application.

From a policy standpoint, this study underscores the essential role of local governments in both developing sustainability regulations and guaranteeing their effective implementation at the local level. The low prioritization of institutional factors suggests a gap between existing policies and their on-the-ground implementation. Institutional capacity building should therefore focus on developing technical policies that are more responsive to the socio-economic and ecological characteristics of each destination. This may involve producing clearer operational guidelines, providing incentives for environmentally responsible businesses, and integrating sustainability certification into the tourism licensing system.

Additionally, the significance of the social dimension in supporting sustainable supply chains emphasizes the need for a more structured community engagement strategy. Such involvement should go beyond symbolic participation and be realized through genuine roles for local communities in planning, managing, and monitoring tourism activities. Strengthening community institutions, such as tourism awareness groups and

local cooperatives, can serve as strategic channels for building collective ownership and responsibility for sustainability. Relevant training, improved market access, and support for innovation in culturally and environmentally based products should also be considered essential components of empowerment strategies.

In conclusion, the success of SSCM implementation depends not only on technocratic approaches but also on how well sustainability strategies address local needs and empower communities meaningfully. A community-based development model plays a vital role in shaping tourism destinations that are not only competitive but also sustainable in ecological, economic, and social terms.

CONCLUSION

This study concludes that the implementation of Sustainable Supply Chain Management (SSCM) in the tourism sector is shaped by the interplay of environmental, social, economic, and institutional factors. The findings indicate that environmental, social, and institutional sustainability positively and significantly influence SSCM adoption, whereas excessive emphasis on economic factors may impede sustainability efforts. Moreover, adopting SSCM improves tourism destination performance by enhancing tourist satisfaction, destination reputation, and local economic development. These conclusions are based on a careful and structured analysis using SEM-PLS to examine causal relationships, and Fuzzy AHP to prioritize strategic dimensions, providing both statistical rigor and stakeholder-based insights.

Given these results, it is recommended that tourism policymakers enhance institutional support, strengthen

policy enforcement, and promote sustainability incentives. Destination managers are encouraged to integrate sustainability into their operational strategies, and local communities should be actively engaged in every phase of tourism planning and management. These efforts are essential to ensure that SSCM serves not only as a management tool but also as a foundation for building competitive, inclusive, and environmentally responsible tourism destinations. Future studies may explore context-specific SSCM frameworks to support policy formulation and improve sustainability outcomes in diverse regional settings.

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