

Tailoring sustainable tourism indicators: Addressing the unique challenges of small island provinces in Indonesia

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Abstract

Indicators for sustainable tourism on small islands should not be equated with those used for the mainland. Studies focusing on small islands further highlight significant limitations in transportation access, infrastructure, water availability, investment capacity, etc. These constraints must be carefully considered when developing appropriate and effective sustainability indicators for tourism in small islands. This 2025 study employed Multidimensional Scaling (MDS) to assess the sustainability of tourism development across Indonesia's priority destinations. The dataset covers 7,158 islands across 12 priority tourism destination provinces. Monte Carlo analysis shows that island provinces perform well in the social and environmental dimensions. These findings highlight the need to integrate local social and environmental considerations into tourism planning and policy, particularly in small island regions where sustainability is crucial for long-term resilience. However, small island provinces perform poorly in the economic and physical dimensions of tourism sustainability. Their geography leads to the limited availability of clean water, infrastructure, high transportation costs and limited access to investment. Island Provinces such as Bangka Belitung, West Nusa Tenggara, North Maluku, Southeast Sulawesi, and East Nusa Tenggara exemplify these challenges. In contrast, non-island provinces demonstrate stronger sustainability in the economic and physical dimensions due to better infrastructure and greater investment capacity. Our research findings, which emphasize a major challenge faced by Small Island Developing States (SIDS): the systemic imbalance in the global financial architecture, infrastructure, water availability, and transportation.

Keywords: Economic, environment, island, physical, social, tourism

Introduction

According to data released by the Association of Southeast Asian Nations (ASEAN), the tourism sector has shown a strong recovery following the decline caused by the COVID-19 pandemic (Rillo et al., 2025). This recovery is reflected in the number of international tourist arrivals to ASEAN member countries, which had reached approximately 92% of pre-pandemic levels by 2025. In several ASEAN countries, including Vietnam and Laos, international tourist arrivals have even surpassed 2019 levels. Meanwhile, other ASEAN member states, such as Malaysia and Indonesia, have experienced an almost complete recovery, with international tourist arrivals reaching approximately 96% of pre-pandemic levels by the end of 2025 (Rillo et al., 2025).

Indonesia's primary tourist attractions are its small islands, which boast an abundance of sun, sea, and sand (3S), thereby offering immense potential for attracting tourists. Considering the tourism industry's dominant role in driving the economies of small islands, stakeholders must prioritize proactive and adaptive management to address the ongoing changes and challenges facing these islands. In response, research in the Seribu Archipelagic, Lombok Island, Karimun Jawa Island, Natuna Island has demonstrated that sustainable tourism is a more suitable approach for small island tourism development (Putri et al., 2025). Further research has highlighted the opportunities and challenges associated with implementing sustainable tourism development models, emphasizing the importance of strategic planning and management (Jones & Walmsley, 2022).

In the context of island nations, sustainable tourism development is intricately linked to conservation efforts (Alvarado-Vanegas & Coromina, 2024; Gravitiani et al., 2024; Shumka et al., 2022; Tran & Caldicott, 2022; Triyono et al., 2025). The issue of sustainable tourism development has been a persistent dilemma in Indonesia, characterized by a significant imbalance in tourism distribution across the archipelago. Notably, Bali, with a land area of less than 1%, receives approximately half of the country's total foreign visitors (Tranter et al., 2022), leading to uneven pressure on marine protected areas and other tourist destinations.

The importance of local stakeholder engagement and addressing community needs, such as basic services, health, and education, in achieving sustainable tourism development in Puerto Ayora, Santa Cruz Island (Burbano et al., 2022). Our study builds on this finding by incorporating variables related to basic services, including road infrastructure, electricity, education, and security, which are integral to the social and physical dimensions of sustainability. This approach is consistent with the Ecotourism Model's emphasis on integrating tourism development with conservation objectives. A crucial aspect of this approach is to ensure the long-term sustainability of local livelihood sources, which in turn supports the achievement of both conservation and tourism goals.

External crises can have far-reaching and adverse consequences for tourist destinations (Goktepe et al., 2024). In response, a collaborative effort between governments and stakeholders is necessary to develop and implement effective strategies for restoring tourism conditions. However, the strategies employed by various countries to restore the tourism industry often focus on individual responses from destinations and industry stakeholders, potentially overlooking the critical role of the central government (Jiang et al., 2019). Furthermore, strengthening social aspects, such as social responsibility initiatives (Blanco-González et al., 2023), is also crucial in restoring tourists' trust in a destination. Tourism sustainability encompasses not only social aspects but also economic, environmental, and

cultural/physical aspects.

Numerous studies have explored tourism sustainability in small islands (Day, 2022; Fernandez-Abila et al., 2024; Grilli et al., 2021; Wang et al., 2025). However, tourism development on small islands cannot effectively adopt the growth pole model theory (Perroux, 1955). Studies focusing on small island regions further highlight significant limitations in transportation access (Amin et al., 2024; Fatima & Husein, 2021; Fernandes & Pinho, 2017; Gurning et al., 2022; Karlsson, 2000; Kawasaki et al., 2021; Prasetiawan et al., 2022; Renes, 2014; Renur et al., 2019; Yashalova & Ruban, 2023), water availability (Renes, 2014) and investment capacity (Benzaken et al., 2024). These constraints must be carefully considered when developing appropriate and effective sustainability indicators for tourism in small island contexts. Therefore, to accurately assess the sustainability of tourism on small islands, it is crucial to develop indicators that reflect their distinct characteristics.

This limitation arises because small islands possess distinct geographical, ecological, and socio-economic characteristics that differ significantly from those of mainland regions (Stratford et al., 2011). These unique attributes require tailored development strategies that account for the islands' limited resources, environmental sensitivity, and economic vulnerabilities. In this context, adopting a sustainable tourism development approach is essential to ensure that tourism activities do not exceed the island's ecological limits, thereby preserving natural resources and supporting long-term community well-being. (Baldacchino, 2024). Our research offers a unique contribution by comparing tourism sustainability in 12 priority locations in Indonesia (The dataset covers 7,158 islands), as determined by government decrees, with a categorization into island provinces and non-island provinces.

Literature review

Numerous studies have explored tourism sustainability in the context of small islands (Fernandez-Abila et al., 2024; Grilli et al., 2021). Therefore, to effectively assess the sustainability of tourism on small islands, it is essential to develop indicators that reflect their unique characteristics. It is hoped that future studies will focus on developing tailored indicators that more accurately capture the distinct attributes of small islands, rather than relying on frameworks designed for mainland contexts.

The concept of sustainability in tourism development encompasses three key dimensions: economic viability, environmental preservation, and social equity. Implementing sustainability within the tourism sector, therefore, requires clearly defined indicators to effectively measure its progress and impact (Araújo Vila & Otegui Carles, 2026). Recent scholarly work highlights the importance of sustainable tourism indicators to guide effective implementation (Font et al., 2023; Miller & Torres-Delgado, 2023; Scuttari et al., 2025). Key programs to ensure a sustainable balance include promoting environmental conservation, ensuring local communities benefit from interpretive tourism (economic), preserving cultural heritage, increasing community participation and empowerment, and encouraging the adoption of sustainable tourism practices (Romadhon et al., 2025).

Firstly, social dimension, for instance, involves fostering social capital at the destination, including building networks, shared norms, and trust among stakeholders (Prayitno et al., 2024). Effective sustainable tourism development also necessitates active collaboration and coordination among stakeholders to ensure that tourism contributes

positively to the well-being of local communities while preserving environmental integrity and promoting long-term regional resilience (Naumov & Lovell, 2026).

In sustainable tourism development, small island communities play a crucial role, as their unique social norms and cultural practices influence how they respond to external pressures (Lattas, 2007). These norms are shaped by their geographic isolation, which fosters strong community bonds, distinct local identities, and self-reliant behaviors. As a result, sustainable tourism initiatives on small islands must be community-centered, ensuring that development aligns with local values, preserves cultural integrity, and enhances community resilience.

The social dimension, for instance, involves fostering social capital at the destination, including building networks, shared norms, and trust among stakeholders. Sustainable tourism involves the strategic management of tourist destinations to ensure long-term viability and success (Butler, 2025), thereby promoting the sustainability of environmental resources, social cohesion, and economic growth.

Second, economic dimension, studies in Belitung Island have revealed a significant transformation in the local economy, with a shift from primary sector activities such as fisheries and mining to a tertiary sector focus on tourism (Mira & Yusuf, 2019). The tourism sector as a key contributor to GDP and a driver of national development (Karimov et al., 2025). One approach to promoting sustainable tourism is through the implementation of a tourism tax. This tax aims to balance public revenue generation with the sustainability of local communities and the competitiveness of the tourism sector. However, it has become a topic of public debate, as it places the financial burden on non-residents (Rosselló-Nadal & Sard, 2026). Therefore, the design and application of such a tax must also consider socioeconomic factors. As part of a broader fiscal policy, the tourism tax should be structured to support sustainable tourism development by addressing social, economic, and environmental dimensions in an integrated and equitable manner.

Third, environmental dimension, a small island expert emphasized that tourism development on small islands must take environmental carrying capacity into serious consideration (Baldacchino, 2024). However, in Table 1, the marine ecosystems in small island regions are highly susceptible to degradation due to human activities (Suryawan et al., 2025). Coral reefs are vulnerable to direct human impacts such as overfishing, pollution, and unregulated tourism but also to broader threats like climate change. Given the ecological fragility of small islands, developing sustainable tourism is essential to mitigate these pressures and preserve marine biodiversity for future generations. If tourism is to serve as a key driver of economic growth, adherence to sustainable tourism principles is essential. Market trends show a growing preference for environmentally responsible tourism, especially among visitors from developed countries.

Table 1. The importance of implementing sustainable tourism in small island regions

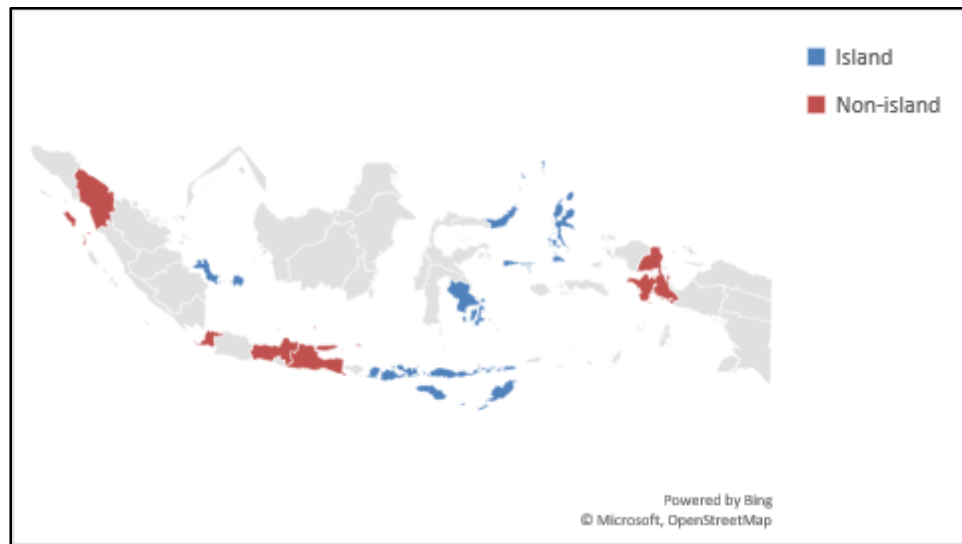
The importance of implementing sustainable tourism in small island regions	Source
Vulnerability of marine ecosystems to human-induced degradation	Suryawan et al., 2025; Thiagarajan & Devarajan, 2025
Development pressures and land limitations: a growing vulnerability	Romadhon et al., 2025

Prioritizing environmental carrying capacity in small island tourism development	Baldacchino, 2024
Challenges of small islands: limited resources, environmental sensitivity, and economic vulnerability	Fernandez-Abila et al., 2024; Grilli et al., 2021; Wang et al., 2025; Fang et al., 2024; Chi & Liu, 2023; Day, 2022
The influence of social norms and cultural practices on small island communities' response to external pressures	Lattas, 2007
Overtourism: its impact on local communities, visitor experience, and environmental sustainability	United Nations World Tourism Organization; UNWTO, 2018; Genç et al., 2022
Sustainable tourism's positive impact on community well-being, environmental preservation, and regional resilience	Naumov & Lovell, 2026
Prioritizing proactive and adaptive management for small island sustainability: challenges facing these islands	Hall et al., 2017; Jones & Walmsley, 2022
Ensuring sustainable livelihoods to achieve conservation and tourism goals	Meredith et al., 2021
Distinctive characteristics of small islands compared to mainland regions	Stratford et al., 2011

Source: Data processed, 2025

Method and study area

The research was conducted in 2025 across 12 priority tourism destination provinces (The dataset covering 7,158 islands), as designated by Cabinet Secretariat Letter No. B-652/Seskab/Maritim/11/2015 and Presidential Regulation No. 18 of 2020 concerning the 2020–2024 National Medium-Term Development Plan (RPJMN). These provinces include six archipelagic provinces Bangka Belitung, Southeast Sulawesi, North Maluku, East Nusa Tenggara, West Nusa Tenggara, and North Sulawesi as well as six non-island provinces: North Sumatra, Central Java, East Java, DKI Jakarta, Banten, and Southwest Papua (Figure 1). According to the Draft Law on Archipelagic Regions (2021), eight provinces have been designated as archipelagic provinces: Riau Islands, Bangka Belitung Islands, West Nusa Tenggara, East Nusa Tenggara, North Sulawesi, Southeast Sulawesi, Maluku, and North Maluku (Ardini, 2022). These provinces have been consolidated under the Archipelagic Regional Cooperation Agency (BKSDK) to facilitate coordinated development and cooperation.



Note: Island (blue)= represents the island provinces, non-island (red)= represents the non-island provinces

Figure 1. Location of the research

This study utilized secondary data sourced from the Central Bureau of Statistics and the National Development Planning Agency. In the data processing phase, the primary data utilized is from the year 2023. Additionally, time series data from 2017 to 2022 will be collected to establish value ranges for scoring purposes, specifically to determine classifications from low to high. The data was gathered from 12 designated research locations and categorized into four key dimensions: economic, social, environmental, and physical. As presented in Table 2, each dimension comprises approximately 6 to 7 attributes or variables. The collected data is categorized into specific dimensions.

Table 2. Research analysis unit

No.	The provinces	The total number of islands
1	Bangka Belitung Archipelagic	507
2	South Sulawesi	370
3	North Maluku	901
4	East Nusa Tenggara	609
5	West Nusa Tenggara	280
6	North Sumatera	229
7	East Java	512
8	North Sulawesi	353
9	Central Java	71
10	Jakarta	113
11	Banten	131
12	Southwest papua	3,082
Total		7,158

Source: BPS, 2025

This study utilizes multidimensional scaling (MDS) techniques. That research applied five key dimensions: ecological, economic, social, technological, and governance to assess tourism management. The multidimensional scaling (include leverage analysis and Montecarlo Analysis) analysis method is a type of cluster analysis used to explore the factors influencing a specific unit of analysis. In the study by Lopes & Estevão, (2024), MDS was applied to examine two distinct research clusters in Latin America: the first comprised competitive countries, while the second included less competitive countries. The analysis focused on identifying key factors influencing the development of sustainable tourism innovations within each cluster.

Table 3. Dimensions, attribute, type of data, and source of data

Dimensions	Atribut/variable	Sources
Economic	Grdp per capita	Central Bureau of Statistics
	Minimum wage	Central Bureau of Statistics
	Tourism sector workforce	Central Bureau of Statistics
	Number of domestic tourist visits	Central Bureau of Statistics
	Number of international tourist visits	Central Bureau of Statistics
	Investment	Central Bureau of Statistics
Environmen t	Environmental pollution	Central Bureau of Statistics
	Regional budget allocation for the environment	Central Bureau of Statistics
	Availability of clean water	Central Bureau of Statistics
	Sanitation system	Central Bureau of Statistics
	Disaster management	National Development Planning Agency
	Environmental awareness	Central Bureau of Statistics
Social	Waste management	National Development Planning Agency
	Unemployment	Central Bureau of Statistics
	Satisfaction with household income	Central Bureau of Statistics
	Conflict	Central Bureau of Statistics
	Community satisfaction	Central Bureau of Statistics
	Education	Central Bureau of Statistics
Physical	Security	Central Bureau of Statistics
	Poverty	Central Bureau of Statistics
	Transportation	Central Bureau of Statistics
	Condition of road infrastructure	Central Bureau of Statistics
	Condition of electrical infrastructure	National Development Planning Agency
	Internet and communication facilities	National Development Planning Agency
	Availability of accommodations	Central Bureau of Statistics
	Availability of restaurants	Central Bureau of Statistics

Source: authors' compilation

The analysis incorporated 45 attributes through MDS to identify the critical factors influencing sustainable tourism (Table 3). Our research is grounded in established indicators developed by the United Nations World Tourism Organization (UNWTO), the Indonesian Ministry of Tourism, along with additional sources cited in the introduction and literature review. Owing to limitations in data availability particularly those associated with the multiple units of analysis and the time-series structure of the dataset the study employed a selected subset of 45 indicators.

The assessment of sustainability has evolved to encompass not only economic, environmental, and physical, but also socio-cultural. This study incorporates the social dimension as a key element, aligning with the approach (Maryono et al., 2019), which includes factors such as conflict and poverty. A study employing multicriteria decision analysis by Estêvão et al., (2019) applied this methodology to various tourist destinations in Portugal. Notwithstanding the establishment of four pillars of sustainable tourism by the Indonesian Ministry of Tourism and Creative Economy, accompanied by 108 indicators to evaluate the sustainability of tourist attractions (Putri et al., 2025), the implementation of genuine sustainable tourism practices remains inadequate, particularly in addressing the unique challenges faced by small island destinations.

The selection of the 45 indicators was guided by a systematic screening process rather than by ad hoc reduction. Although the sustainable tourism framework developed by the Indonesian Ministry of Tourism comprises 108 indicators and UNWTO, the indicators retained for this study were selected to ensure comprehensive coverage of the four sustainability dimensions while maintaining data availability and cross-provincial comparability. Where multiple indicators captured similar constructs, a single representative indicator was selected to reflect the underlying dimension. This approach minimized redundancy while preserving analytical scope.

For example, within the economic dimension, the Ministry's framework includes 23 indicators organized across eight thematic categories. The six economic indicators employed in this study represent six of these eight categories. The remaining two categories, pertaining to unemployment and poverty, were reclassified under the social dimension. This reclassification reflects their closer alignment with social welfare outcomes at the provincial level and is consistent with their treatment as social development indicators in the sustainable development literature.

Similarly, for the environmental dimension, the Ministry's framework includes 29 indicators distributed across eight categories, whereas this study utilizes seven representative indicators. Collectively, these indicators capture seven of the eight environmental categories. The category excluded from the analysis was carbon emissions, due to the absence of consistent provincial-level time-series data throughout the study period. The indicators employed are predominantly those established by the UNWTO. This choice is warranted by the high degree of congruence between the UNWTO indicator framework and that of the Indonesian Ministry of Tourism, thereby ensuring international comparability while maintaining national policy relevance. Thus, the omission was attributable to data constraints rather than to methodological preference.

Results and discussion

Figure 2 shows that the results of the economic ordination reveal the lowest levels of tourism development sustainability in island provinces, particularly Southeast Sulawesi and Bangka Belitung. In contrast, non-island provinces such as East Java, Jakarta, and Central Java exhibit the highest economic ordination scores. The economic ordination analysis indicates that the attribute of investment levels in small island areas is significantly low, limiting their capacity to support sustainable tourism development.

Our research findings are consistent with Benzaken et al., (2024), which highlights one of the key challenges faced by Small Island Developing States (SIDS): the systemic imbalance within the global financial architecture. This imbalance contributes to structural vulnerabilities in small island regions, particularly in the context of tourism development. Based on this analysis, small islands exhibit limitations in investment indicators that differ significantly from those of non-island provinces. This disparity underscores the necessity of distinguishing sustainability indicators for small islands, as they cannot be directly equated with those used for mainland regions. In response, several scholars specializing in small island studies advocate for the strengthening of financial support systems, the introduction of technologies adapted to the unique characteristics of small island communities, and the integration of local knowledge (Adger, 2010; Barnes et al., 2017; Blythe et al., 2022; Fried et al., 2022; Levy & Lubell, 2018). In Figures 2, 3, 4, 5, 10, 11, and 12, the abbreviations are defined as follows: U = Upper confidence limit; B = Bad; D = Developing; and G = Good. In addition, the provincial abbreviations used in Figures 2–12 are as follows: Sultra = Southeast Sulawesi; Babel = Bangka Belitung; Pabar = Southwest Papua; Sulut = North Sulawesi; NTT = East Nusa Tenggara; Sumut = North Sumatra; Malut = North Maluku; NTB = West Nusa Tenggara; Banten = Banten; Jateng = Central Java; Jakarta = DKI Jakarta; and Jatim = East Java.

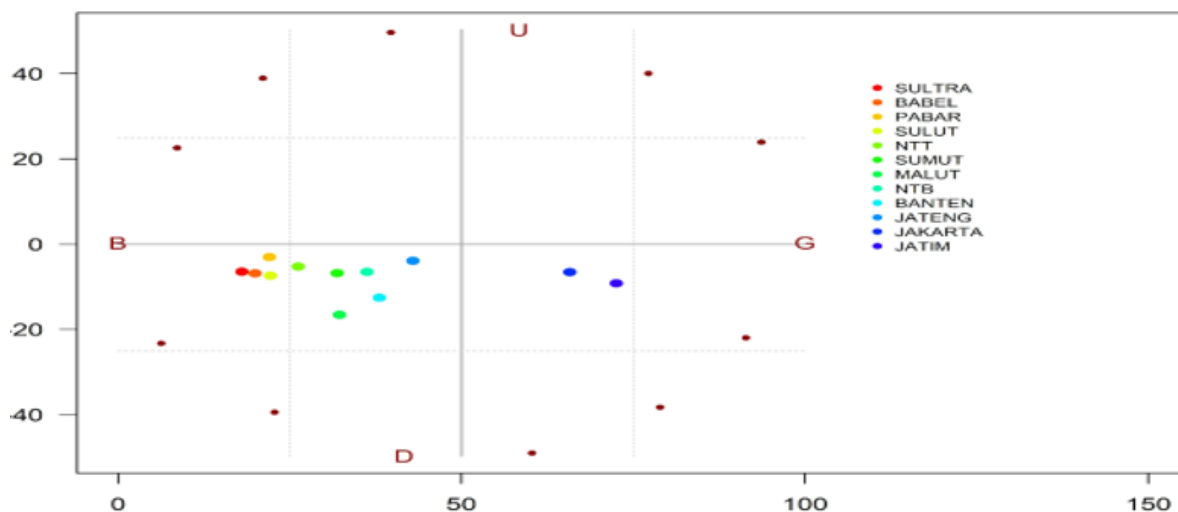
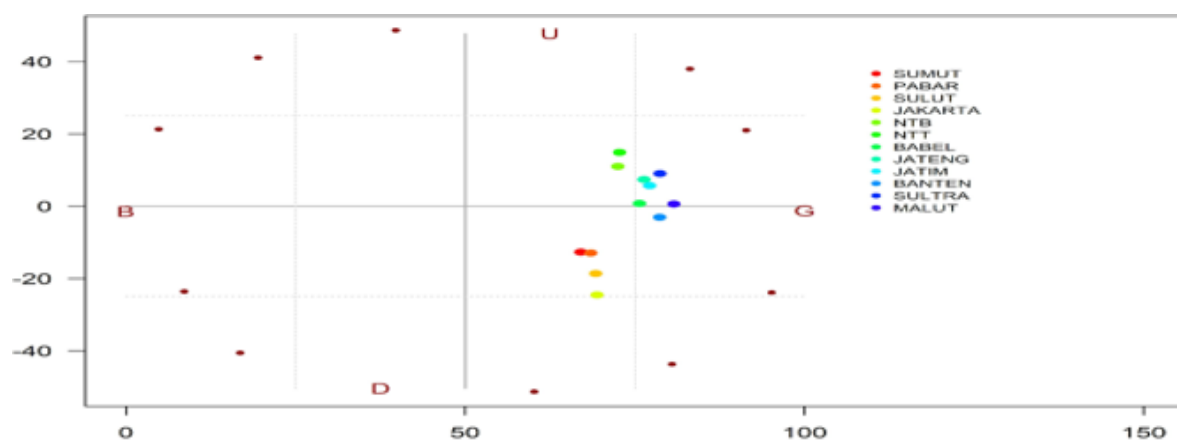


Figure 2. Ordinance on economic dimensions of sustainable tourism

Conversely, in the social dimension (Figure 3), several island provinces demonstrate relatively high levels of sustainable tourism. Notably, North Maluku and Southeast Sulawesi rank among the highest. In contrast, some non-island provinces perform poorly in social dimensions. North Sumatra and Southwest Papua, for instance, show low social sustainability

tourism scores. Research by Chauvel (2021) highlights ongoing conflict in the Papua region, where resistance from certain local communities toward the Indonesian government contributes to social instability. Conflict, a critical attribute in the social dimension, significantly affects these provinces. The independence movement in Papua, characterized by localized and sporadic rebellions and armed resistance, was met with responses from the Indonesian military aimed at maintaining national security and political stability (Chauvel, 2021). However, these military responses were perceived by separatist groups as disproportionately dominant in relation to the scale of the armed resistance. Additionally, Southwest Papua and North Sumatra are among the regions with the lowest Happiness Index scores (Sumin & Retnawati, 2022), indicating serious challenges in achieving socially sustainable tourism. Addressing these social issues is critical to improve both tourist experience and long-term tourism sector resilience.



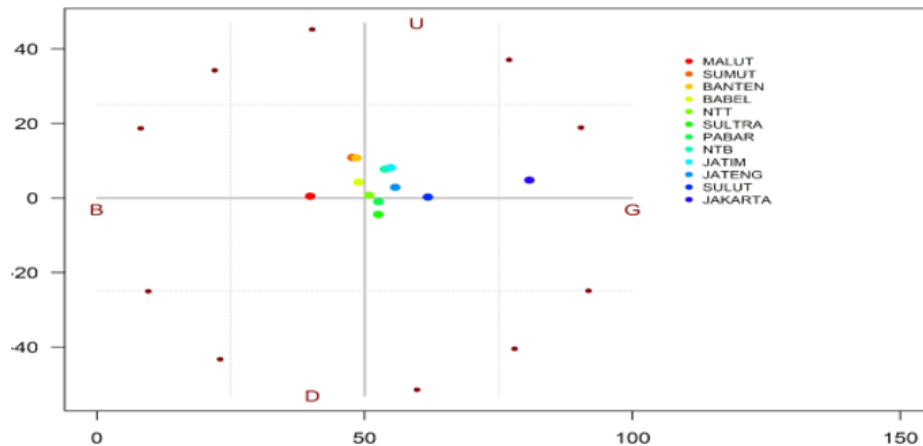


Figure 4. Ordinance on environmental dimensions of sustainable tourism

In the physical dimension (Figure 5), island provinces rank lower in sustainable tourism development, with Bangka Belitung, North Maluku, and West Nusa Tenggara among the bottom three. This is largely due to limited regional budget allocations compared to non-island provinces such as Central Java, East Java, and Jakarta, which score highest in this dimension. Adequate budget allocation is essential for developing infrastructure-related attributes, including transportation, road networks, and electricity key components for sustainable tourism. Many island regions face logistical challenges due to their geographic isolation (Karlsson, 2000; Renes, 2014), which limits access and increases transportation costs.

This issue is not unique to Indonesia; similar challenges are observed in other island regions such as the Pacific Islands, Greenland, the Dutch Wadden Islands, Ouessant Island in France, and Indonesia's eastern islands, including North Maluku (Amin et al., 2024; Anderson, 2004; Renes, 2014). Various studies have emphasized the critical role of transportation in supporting economic development and tourism sustainability in small island settings (Diamond, 2005; Fatima & Husein, 2021). Consequently, indicators of sustainable tourism development for small islands must be tailored to reflect their specific characteristics and constraints.

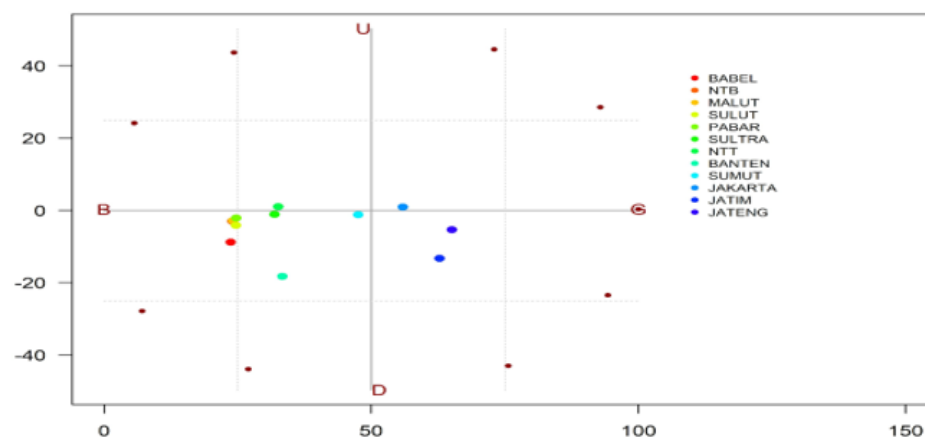


Figure 5. Ordinance on physical dimension of sustainable tourism

Leverage attributes influencing sustainable tourism

Based on the results of the leverage attribute analysis (Figure 6), the number of international tourist arrivals is identified as the most influential factor in the economic dimension of sustainable tourism development, contributing 6.02%. According to Mundi, (2025), increased tourist arrivals significantly benefit local businesses, particularly in small island communities. Experiences from island destinations like the Canary Islands and Caribbean Islands also demonstrate how international tourism can serve as an economic catalyst (González and Lorenzo-Cuyás, 2025), offering alternative livelihoods to communities previously dependent on primary sectors (McGillivray et al., 2008).

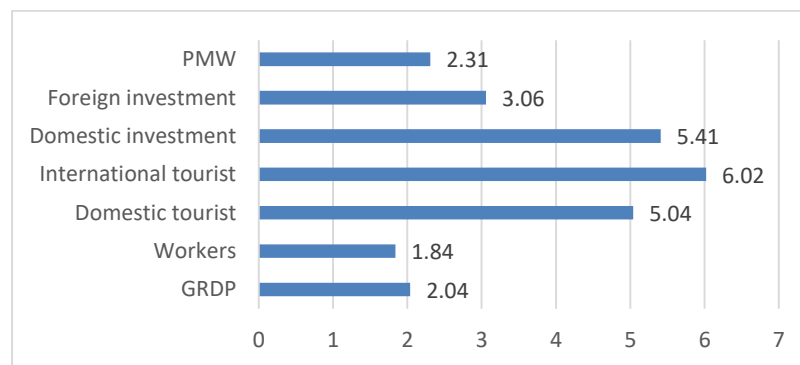


Figure 6. Leverages attribute on economic dimension of sustainable tourism

Figure 7, based on the leverage attribute analysis of the social dimension, shows that the most influential factors on sustainable tourism development are community satisfaction and satisfaction with household income, both contributing 7.16%. In contrast, the crime rate has a relatively lower influence, contributing only 3.35% to the ordination of the social dimension. Most priority tourism destinations in Indonesia are characterized by low crime rates, which contributes to a sense of safety and security for visitors. A contrasting perspective is offered by Vakhitova et al., (2026), who found that tourist destinations can also be hotspots for crime often not perpetrated by locals, but by other tourists. Crime in tourism areas can negatively impact visitor perceptions, leading to a decline in tourist arrivals and, consequently, a downturn in the local economy.

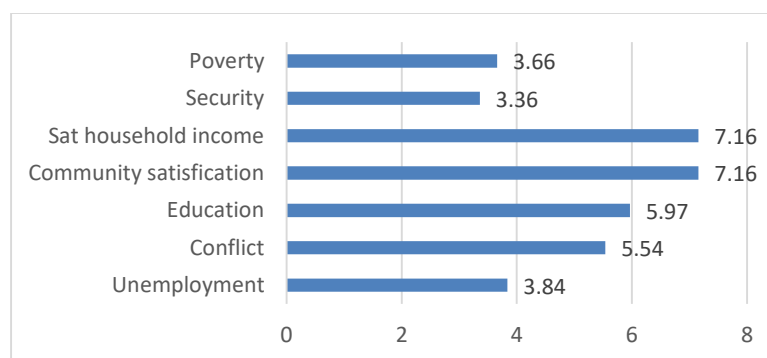


Figure 7. Leverages attribute on social dimension of sustainable tourism

Figure 8, which presents the leverage attribute analysis for the environmental dimension, identifies the availability of clean water as the most influential factor, with a contribution of 9.33%. The critical importance of clean water for sustainable tourism was notably illustrated by the 2018 water crisis in Cape Town, South Africa, (Li et al., 2025). Small island regions are particularly vulnerable to clean water scarcity, due to their geographic and ecological limitations (Karlsson, 2000; Renes, 2014). In Indonesia, strategic efforts have been implemented to mitigate this issue, such as the installation of Seawater Reverse Osmosis (SWRO) systems on several small islands to improve access to potable water (Wening Purwandari et al., 2021). In contrast, environmental pollution was found to have the least influence on the sustainability of tourism in these regions, with a weight of only 1.64%. This is largely because many priority tourism destinations are situated far from industrial zones and urban centers.

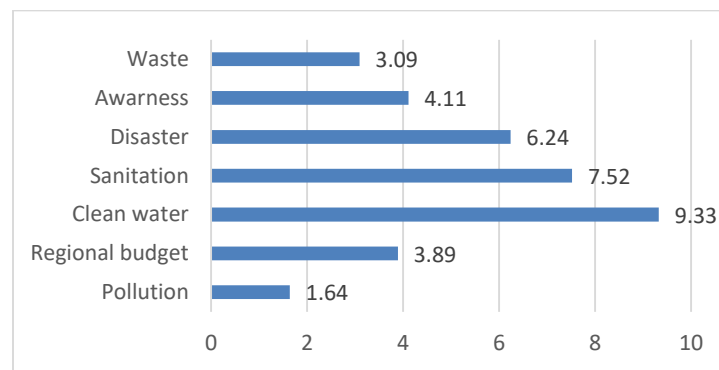


Figure 8. Leverages attribute on environmental dimension of sustainable tourism

Figure 9 presents the results of the leverage attribute analysis for the physical dimension, indicating that the availability of restaurants exerts the greatest influence on the sustainability of tourism development, with a contribution of 8.02%. One of the key factors that can attract tourists to a destination is its culinary offerings or gastronomy (Yang et al., 2024). Small island regions possess distinct culinary characteristics shaped by their geographic isolation and natural environment. This uniqueness provides a competitive advantage, positioning small islands as attractive and differentiated tourist destinations.

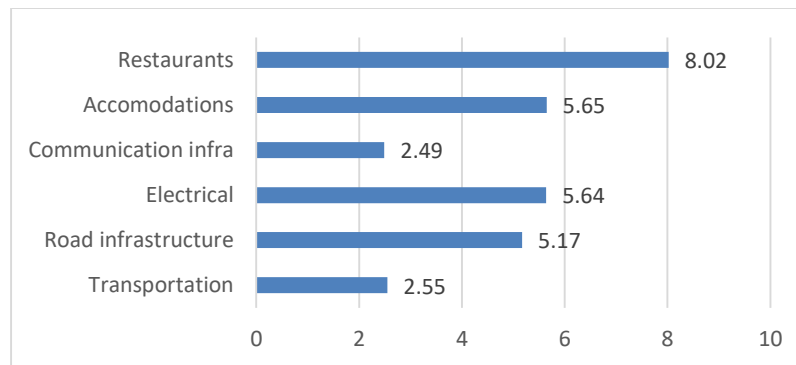


Figure 9. Leverages attribute on physical dimension of sustainable tourism
Montecarlo analysis of sustainable tourism development

Figure 10 presents the results of the Monte Carlo analysis for the economic dimension, revealing that seven provinces have demonstrated weak implementation of sustainable tourism practices. The majority of these are island provinces, including Southeast Sulawesi, Bangka Belitung, North Sulawesi, East Nusa Tenggara, North Maluku, and West Nusa Tenggara. This underperformance is primarily attributed to low levels of both domestic and foreign investment, low per capita Gross Regional Domestic Product (GRDP), and lower provincial minimum wages (UMR) in these regions. Island provinces often face structural disadvantages such as high transportation costs and a heavy reliance on the primary sector, which hinder their access to financial capital and development opportunities. Such efforts are critical to building resilience and achieving long-term sustainable development (Adger, 2010; Blythe et al., 2022).

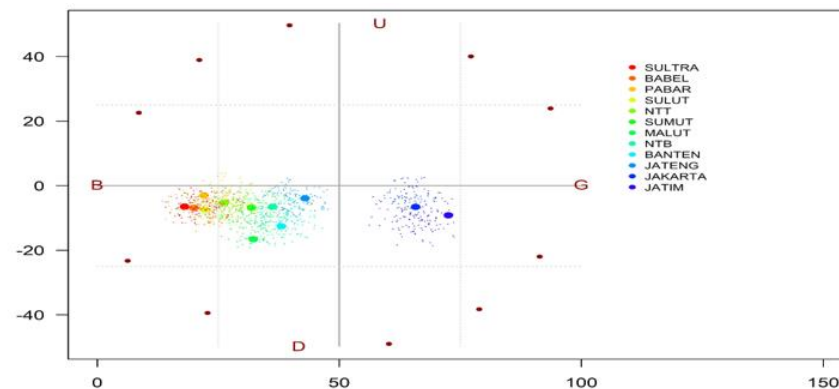


Figure 10. Montecarlo analysis on economic dimension of sustainable tourism

Figure 11 presents the results of the Monte Carlo analysis for the social dimension. Unlike the economic dimension, island provinces demonstrate strong implementation of sustainable tourism in the social aspect. Notably, North Maluku, North Sulawesi, and Bangka Belitung consistently rank high on Indonesia's Happiness Index (Sumin & Retnawati, 2022), an essential indicator within the social dimension, as it reflects the overall well-being and satisfaction of local communities.

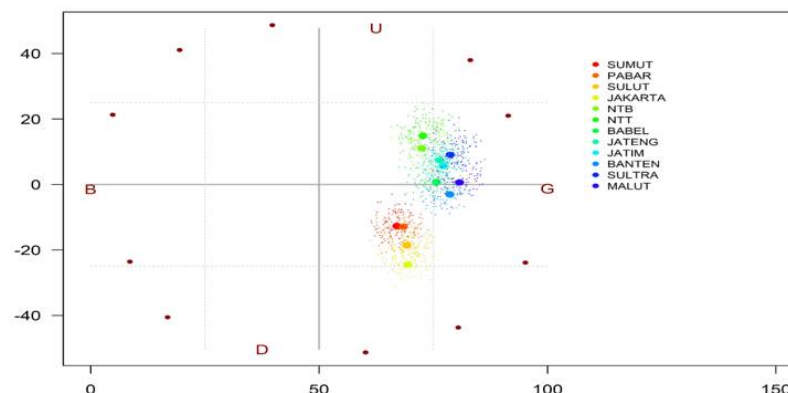


Figure 11. Montecarlo analysis on social dimension of sustainable tourism

Figure 12 presents the results of the Monte Carlo analysis for the environmental dimension. Among the findings, East Nusa Tenggara an island province was identified as highly unsustainable in terms of environmental performance. This low score is attributed to severe shortcomings in key environmental indicators, particularly the availability of clean water, inadequate sanitation systems, and limited regional budget allocations for environmental management. As a small island province with distinct geographical and ecological characteristics (Dahuri, 1998), East Nusa Tenggara faces inherent challenges, particularly in securing clean water resources.

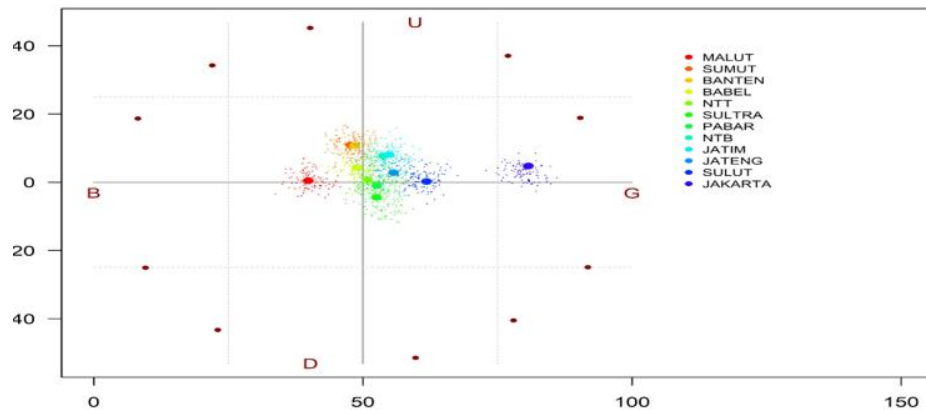


Figure 12. Montecarlo analysis on environmental dimension of sustainable tourism

Conclusion

The Monte Carlo analysis reveals that island provinces demonstrate strong performance in implementing sustainable tourism, particularly in the social and environmental dimensions. In the social dimension, this positive outcome is closely linked to high scores in key attributes such as community satisfaction and satisfaction with household income. These findings underscore the importance of incorporating localized social and environmental factors into tourism planning and policy especially in small island regions where sustainability is not only a development goal but a necessity for long-term resilience.

In contrast, the economic and physical dimensions of sustainable tourism in small island provinces are characterized by significantly low sustainability scores. These shortcomings are largely attributable to the inherent geographic isolation of small islands, which poses substantial challenges to the development and maintenance of physical infrastructure. Key attributes contributing to these deficiencies include limited transportation networks, underdeveloped electricity infrastructure, inadequate communication and internet connectivity, and insufficient availability of accommodations. Provinces that exemplify these challenges include Bangka Belitung, West Nusa Tenggara, North Maluku, Southeast Sulawesi, and East Nusa Tenggara.

On the other hand, non-island provinces such as Central Java, East Java, Jakarta, North Sumatra, and Banten demonstrate strong implementation of sustainable tourism, particularly in the economic and physical dimensions, supported by better infrastructure and greater

investment capacity. This low score is attributed to severe shortcomings in key environmental indicators, particularly the availability of clean water, inadequate sanitation systems, and limited regional budget allocations for environmental management.

Studies focusing on small island and our research further highlight significant limitations in transportation access, infrastructure, water availability, and investment capacity. This imbalance creates structural vulnerabilities that significantly impact the sustainability of tourism development in small island regions. Based on the leverage attribute analysis, international tourist arrivals emerge as the most influential factor in the economic dimension of sustainable tourism development, contributing 6.02%. These visits play a crucial role in stimulating the local economy, especially in small island communities. According to Mundi (2025), an increase in international tourist arrivals significantly boosts local businesses.

These findings highlight the need for tailored development strategies that address the unique vulnerabilities of small islands rather than applying a one-size-fits-all growth model. The study underscores the need for government policies to consider the unique vulnerabilities of small islands rather than relying solely on traditional development models.

Recommendations/policy implications

The findings of this study have important policy implications for advancing sustainable tourism development in Indonesia's small-island regions. A comprehensive policy framework is needed to address the structural constraints that limit sustainability, particularly in the physical and economic dimensions. Improving transportation infrastructure should be a strategic priority through increased flight frequency, more reliable schedules, affordable airfares, and integrated multimodal transport systems linking airports, seaports, and major tourism destinations. Such investments are especially important in East Nusa Tenggara, West Nusa Tenggara, West Papua, and North Maluku, where many attractions remain geographically isolated.

The study also highlights the need to strengthen electricity infrastructure, internet connectivity, and tourism accommodations in provinces such as Bangka Belitung, North Maluku, Southeast Sulawesi, and East Nusa Tenggara. Accelerating digital transformation through integrated online reservation systems, digital marketing, and cashless payment infrastructure would improve destination accessibility, enhance visitor experiences, and increase the competitiveness of community-based tourism (CBT) enterprises.

Water security should also become a policy priority, particularly in drought-prone regions such as East Nusa Tenggara. Although reservoirs (*embung*) provide an important source of seasonal water storage, their effectiveness is constrained by limited capacity and high evaporation rates. Consequently, reservoir development should be integrated with watershed conservation, reforestation, groundwater recharge through infiltration wells, spring protection, and rainwater harvesting to improve long-term water resilience.

From an economic perspective, expanding access to affordable business credit through formal banking institutions is essential to overcome investment constraints faced by tourism MSMEs. The experience of Southeast Maluku demonstrates that formal banking can successfully finance CBT enterprises while preserving community ownership and local decision-making, reducing dependence on external investors.

The successful implementation of these policy recommendations ultimately depends

on strong partnerships among governments, the private sector, financial institutions, and local communities. Such collaborative governance can mobilize investment, strengthen local capacity, promote innovation, and improve infrastructure while ensuring that tourism development remains inclusive, resilient, and environmentally sustainable in Indonesia's small-island regions.

Limitations and future research directions

Studies focusing on small island further highlight significant limitations in transportation access, water availability, and investment capacity. To accurately assess the sustainability of tourism on small islands, it is crucial to develop indicators that reflect their distinct characteristics. Future research should prioritize the creation of tailored indicators that address the challenges of small islands. Future research should expand the sustainable tourism assessment framework by incorporating dimensions that reflect the unique characteristics and vulnerabilities of small islands. These dimensions may include climate change resilience (e.g., coastal erosion, sea-level rise adaptation, and disaster preparedness), marine ecosystem sustainability (e.g., coral reef condition, mangrove conservation, seagrass protection, and marine biodiversity), freshwater security (e.g., water availability, rainwater harvesting, and water-use efficiency), marine waste management (e.g., plastic waste management, coastal cleanliness, and wastewater treatment), and island connectivity and accessibility (e.g., air and maritime connectivity, internet accessibility, and the reliability of transport services).

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Declaration of competing/conflicting interests

The authors declare that there are no competing interests associated with the conduct of this research. This study has been conducted in accordance with international ethical and legal standards for research, upholding the principles of confidentiality and respect for human participants' rights, including their right to privacy.

Artificial Intelligence (AI) usage declaration

This manuscript utilized artificial intelligence tools to enhance the English language structure.

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