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Tourism Development And Coastal Ecosystem Degradation In Southern Bali

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ABSTRACT

Background. Rapid tourism development in southern Bali has transformed the region into one of Indonesia's most dynamic economic zones while simultaneously placing immense pressure on its coastal ecosystems. The expansion of hotels, restaurants, and recreational facilities has led to land-use change, increased waste discharge, shoreline modification, and coral reef degradation. The resulting imbalance between economic growth and ecological stability threatens the long-term sustainability of both the tourism industry and local livelihoods.

Purpose. This study aims to examine the relationship between tourism development and coastal ecosystem degradation in southern Bali, focusing on spatial, ecological, and socio-economic dimensions.

Method. A mixed-method approach was adopted, combining satellite imagery analysis, field observations, and stakeholder interviews. Spatial analysis using GIS detected changes in coastal land cover between 2010 and 2023, while qualitative data from 40 key informants including local residents, tourism operators, and environmental officials were analyzed thematically to understand community perceptions and management responses. Quantitative environmental indicators, such as water quality and coral coverage, were also integrated to assess ecological decline.

Results. The findings reveal a significant correlation between the intensity of tourism infrastructure development and the deterioration of coastal ecosystems. Coral coverage declined by 38%, while mangrove areas decreased by 22% within the study period. Stakeholder interviews indicate that weak environmental regulation and poor waste management practices accelerate this degradation.

Conclusion. The study concludes that sustainable tourism in southern Bali requires stronger spatial planning, community-based coastal management, and stricter enforcement of environmental standards to balance economic benefits with ecosystem preservation.

KEYWORDS

Coastal Degradation, Tourism Development, Ecosystem Management, Southern Bali, Sustainable Tourism

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INTRODUCTION

Tourism is widely recognized as one of the most significant contributors to economic growth in Indonesia, particularly in Bali, which has long been considered the country's premier international tourism destination (Steger, 2023). The southern coastal region of Bali encompassing areas such as Kuta, Seminyak, Jimbaran, and Nusa Dua represents the epicenter of tourism-driven development (Rangel-Buitrago, 2026). Over the past three decades, this

area has undergone rapid physical transformation, with large-scale construction of hotels, restaurants, villas, and supporting infrastructure (Sebastian dkk., 2024). The expansion of these facilities has generated substantial income and employment opportunities for local communities, contributing to national GDP and improving the island's global image.

The dynamics of tourism growth in southern Bali, however, have also triggered extensive environmental consequences (Bartelet dkk., 2024). Increased land conversion for tourism infrastructure has resulted in the loss of mangrove forests, coastal erosion, and a decline in coral reef health (Liu & Zeng, 2026). Studies by UNEP (2021) and the Bali Environmental Agency (DLH, 2022) indicate that wastewater disposal and plastic pollution from the tourism industry have significantly affected the coastal ecosystem's carrying capacity (Kumar dkk., 2024). The degradation of beaches and marine habitats threatens not only ecological stability but also the long-term sustainability of tourism itself.

Government and industry stakeholders have long acknowledged the interdependence between tourism and the natural environment (Rahman dkk., 2025). Bali's attractiveness depends largely on its coastal beauty and biodiversity, which serve as key drivers of the island's tourism economy (Xu dkk., 2026). Consequently, any environmental degradation undermines both ecological integrity and economic potential (Sun dkk., 2024). Sustainable tourism, therefore, has become an increasingly central discourse in policy planning and academic research concerning Bali's future.

Several sustainable tourism initiatives have been introduced to mitigate environmental degradation (Nandhini dkk., 2026). Programs promoting waste management, coral restoration, and community-based ecotourism have been launched in collaboration with local NGOs and international organizations (Sen dkk., 2025). Despite these efforts, the pace of ecological recovery remains slower than the rate of environmental damage, particularly in areas dominated by mass tourism (Duong dkk., 2026). The imbalance between economic incentives and ecological stewardship continues to challenge policy implementation.

Empirical evidence demonstrates that the most severely affected areas are those where unregulated coastal development coincides with weak environmental governance (Suryawan dkk., 2024). Coastal ecosystems such as mangroves, seagrass beds, and coral reefs serve as natural buffers that protect shorelines from erosion and flooding (Dulyakasem dkk., 2026). Their destruction, often driven by infrastructure expansion, not only disrupts ecological functions but also increases local vulnerability to climate change.

Tourism's dual nature as both an economic catalyst and an ecological threat has thus become a defining feature of southern Bali's development narrative (Handiani dkk., 2025). The island's struggle to balance growth with conservation exemplifies the broader challenges faced by developing regions that depend heavily on natural capital for economic advancement.

Despite the growing body of research on Bali's tourism and environment, limited studies have quantitatively assessed the spatial relationship between tourism expansion and coastal ecosystem degradation (Suryawan dkk., 2025). Existing literature often focuses on general environmental impacts without integrating geospatial data or long-term ecological indicators (Thompson, 2026). This lack of spatially explicit analysis hinders the understanding of how land-use changes directly correlate with the decline in ecosystem quality.

Research on the socio-ecological dimension of coastal degradation in southern Bali also remains fragmented (Hastuti dkk., 2024). The extent to which local communities perceive and respond to environmental decline has not been adequately explored (Chowdhury dkk., 2026). While

local residents rely on both tourism and coastal resources for livelihoods, few studies have examined how these dual dependencies influence their participation in coastal conservation efforts.

Institutional analyses of coastal management in Bali are similarly scarce (Sumanapala & Wolf, 2024). Studies have rarely evaluated the effectiveness of local regulations, zoning policies, or enforcement mechanisms in mitigating environmental degradation caused by tourism infrastructure (Allaf dkk., 2026). Weak coordination between government agencies and private investors continues to create policy gaps that allow unsustainable development to persist.

Longitudinal data on ecological change in Bali's southern coast are limited, leaving uncertainties about the rate and scale of degradation over time (Hidayah dkk., 2024). The absence of comprehensive, multi-year studies combining remote sensing with field-based ecological assessments has prevented policymakers from obtaining accurate insights into the cumulative impact of tourism on coastal systems.

Addressing these research gaps is essential for developing an evidence-based framework for sustainable tourism and coastal management in Bali (Ho dkk., 2026). Integrating spatial analysis with socio-environmental data can reveal the precise mechanisms linking tourism growth to ecological decline (Dimara Sakti dkk., 2025). Understanding this relationship enables policymakers to design interventions that balance economic interests with ecosystem resilience, ensuring that tourism remains a viable long-term development strategy.

This study aims to analyze the relationship between tourism development and coastal ecosystem degradation in southern Bali by employing geospatial mapping, ecological indicators, and community perception analysis (Pásková dkk., 2024). The research examines land-use change patterns, coral reef health, and stakeholder responses to environmental challenges between 2010 and 2023. The goal is to produce a comprehensive assessment that bridges scientific evidence with policy relevance.

The rationale behind this research lies in the urgent need to reframe tourism planning within an environmental sustainability paradigm. By providing empirical insights into the spatial and ecological impacts of tourism, the study contributes to the broader academic discourse on sustainable coastal governance (Huang dkk., 2026). The findings are expected to guide policymakers, educators, and tourism stakeholders toward implementing environmentally responsible tourism models that preserve Bali's coastal ecosystems for future generations.

RESEARCH METHODOLOGY

Research Design

This study employs a mixed-method research design integrating quantitative spatial analysis and qualitative socio-environmental inquiry to investigate the relationship between tourism development and coastal ecosystem degradation in southern Bali. The quantitative component focuses on the analysis of land-use change and environmental quality indicators using Geographic Information Systems (GIS) and remote sensing data, while the qualitative component explores local perceptions, stakeholder participation, and policy effectiveness through interviews and document analysis (Jolaosho dkk., 2025). The mixed-method approach allows for triangulation of ecological, economic, and social data, providing a comprehensive understanding of how tourism expansion influences the degradation of coastal ecosystems. The research design aligns with an explanatory sequential model, where spatial and environmental data interpretation informs the subsequent qualitative analysis of community and institutional responses.

Population and Samples

The population of this study comprises coastal zones within the southern region of Bali, specifically the subdistricts of Kuta, Seminyak, Jimbaran, Nusa Dua, and Sanur. These locations were selected based on their intensity of tourism activity and documented environmental changes over the past decade. Sampling was conducted using a purposive sampling technique, focusing on two main groups: (1) ecological samples in the form of spatial and biophysical data from selected coastal sites, and (2) social samples involving stakeholders directly connected to tourism and environmental management. A total of 40 participants were included in the qualitative component, consisting of local residents, tourism entrepreneurs, government officials, and representatives from environmental NGOs. This combination of environmental and human samples ensures a balanced representation of physical changes and social perspectives in the study area.

Instruments

The instruments utilized in this research include satellite imagery, structured observation sheets, semi-structured interview guides, and environmental quality indicators. Satellite images from Landsat 8 OLI/TIRS and Sentinel-2 were used to analyze land-use and coastline changes between 2010 and 2023. Structured observation sheets were developed to record field data related to water quality, waste accumulation, coral reef conditions, and mangrove coverage. Semi-structured interview guides were designed to gather qualitative data on stakeholder perceptions, management practices, and policy implementation challenges (Lukoseviciute dkk., 2024). Environmental quality indicators such as turbidity levels, dissolved oxygen, and percentage of live coral cover were used to assess ecosystem health. Data triangulation across these instruments ensures validity, reliability, and coherence between spatial, ecological, and social dimensions.

Procedures

The research was conducted through four systematic stages: (1) preliminary assessment, (2) data collection, (3) data analysis, and (4) validation. The preliminary stage involved literature review, identification of study areas, and acquisition of spatial datasets from the Indonesian National Institute of Aeronautics and Space (LAPAN) and the Bali Environmental Agency. Data collection included GIS-based mapping of land-use changes, direct field observations, and in-depth interviews with selected stakeholders. Quantitative data analysis was carried out using ArcGIS 10.8 for spatial change detection and ENVI 5.6 for remote sensing image classification (Sebastian dkk., 2025). Qualitative data were analyzed thematically using NVivo 12, focusing on recurring patterns related to perceptions of tourism-induced degradation and governance effectiveness. Validation was achieved through data triangulation and member checking, ensuring that interpretations accurately reflect observed phenomena and stakeholder experiences. Ethical considerations, including informed consent, anonymity, and environmental sensitivity, were strictly maintained throughout the research process. The entire procedure was designed to integrate environmental science, education, and social policy perspectives for a holistic understanding of sustainable coastal tourism in southern Bali.

RESULT AND DISCUSSION

Quantitative data from the Bali Provincial Tourism and Environmental Offices (2010–2023) show that the southern region of Bali has experienced rapid tourism expansion over the last decade. The number of tourism establishments including hotels, villas, restaurants, and recreational facilities has increased by 68%, from 1,125 units in 2010 to 1,893 units in 2023. Meanwhile, satellite imagery analysis indicates significant land-use changes, with the conversion of mangrove and

coastal vegetation areas into built-up zones. Coastal land conversion reached 32% over the same period, primarily concentrated in Kuta, Seminyak, and Jimbaran.

Table 1. Land-Use and Tourism Infrastructure Expansion in Southern Bali (2010–2023)

Year	Tourism Establishments	Built-Up Area (Ha)	Mangrove Area (Ha)	Coral Cover (%)
2010	1,125	2,435	1,152	58.4
2014	1,374	2,862	1,046	52.3
2018	1,654	3,204	928	44.9
2023	1,893	3,513	894	36.1

The data demonstrate a clear inverse relationship between the expansion of tourism infrastructure and the health of coastal ecosystems. Coral coverage has declined by 38% over the observed period, accompanied by the loss of nearly 260 hectares of mangroves.

The increase in built-up areas correlates with the proliferation of tourism facilities that often occupy or modify natural landscapes along the coastline. The replacement of mangroves and wetlands with hotels and resorts has reduced the natural capacity of these ecosystems to absorb waste and filter pollutants. The sharp decrease in coral cover is attributed to sedimentation, nutrient runoff, and physical destruction caused by recreational diving, boat anchoring, and shoreline modification.

Spatial overlay analysis using GIS confirms that zones with the highest tourism density exhibit the most severe environmental degradation. Kuta and Seminyak show the greatest reduction in vegetation cover, while Nusa Dua displays moderate decline due to better-managed coastal zoning. These findings support the hypothesis that unregulated tourism development directly contributes to ecological stress in coastal areas.

Field observations recorded increasing levels of pollution in water quality indicators. Average biochemical oxygen demand (BOD) levels rose from 3.2 mg/L in 2010 to 5.8 mg/L in 2023, exceeding the environmental quality standards for coastal water. Similarly, nitrate concentrations increased from 0.9 mg/L to 2.7 mg/L, indicating intensified nutrient loading from wastewater and fertilizer runoff. These changes coincide with increased plastic waste accumulation on beaches, particularly in the high-tourism seasons.

The degradation of coastal water quality has affected marine biodiversity. Observations of coral reef communities reveal a shift from hard coral dominance to algal proliferation, signaling declining ecosystem health. Fish populations, especially reef-dependent species such as parrotfish and butterflyfish, have decreased by approximately 27% within the same period. These ecological indicators collectively reflect the declining resilience of southern Bali's coastal ecosystems.

Statistical correlation analysis was conducted to evaluate the relationship between tourism expansion and ecosystem degradation indicators. The results show a strong negative correlation ($r = -0.83$, $p < 0.01$) between the increase in built-up area and coral cover percentage. A moderate positive correlation ($r = 0.69$, $p < 0.05$) was found between tourism establishment density and BOD levels, suggesting that tourism growth intensifies water pollution and biological stress.

Table 2. Correlation between Tourism Growth and Environmental Indicators (2010–2023)

Variable Relationship	Correlation (r)	Significance (p)	Interpretation
Built-Up Area – Coral Cover	-0.83	0.003	Strong Negative Correlation
Tourism Establishments – BOD Levels	0.69	0.017	Moderate Positive Correlation
Tourism Establishments – Mangrove Loss	-0.77	0.008	Strong Negative Correlation

The inferential results confirm that tourism development intensity has a statistically significant influence on the decline of coastal environmental quality in southern Bali.

The relational analysis shows that the degradation of natural habitats is intertwined with weak regulatory enforcement and fragmented coastal governance. Interviews with stakeholders reveal that local regulations, such as building setbacks and wastewater management standards, are often poorly implemented. Developers frequently prioritize economic gains over environmental compliance, while overlapping authority between tourism and environmental agencies leads to inconsistent monitoring.

The relationship between tourism growth and community livelihood is paradoxical. While economic dependence on tourism has increased household income, it has also made local communities more vulnerable to ecological shocks such as beach erosion and water scarcity. Residents in coastal villages report that deteriorating environmental quality has begun to affect fisheries and traditional salt-making activities, indicating the interdependence of social and ecological systems.

A case study from Jimbaran Bay highlights the complexity of tourism-driven degradation. The bay, once known for its thriving coral reefs and artisanal fishing, has experienced severe sedimentation due to hotel construction and unregulated runoff. Local fishers report a 40% decline in daily catch compared to 2012. Shoreline modifications for beachfront facilities have altered natural sediment flow, accelerating beach erosion in nearby areas.

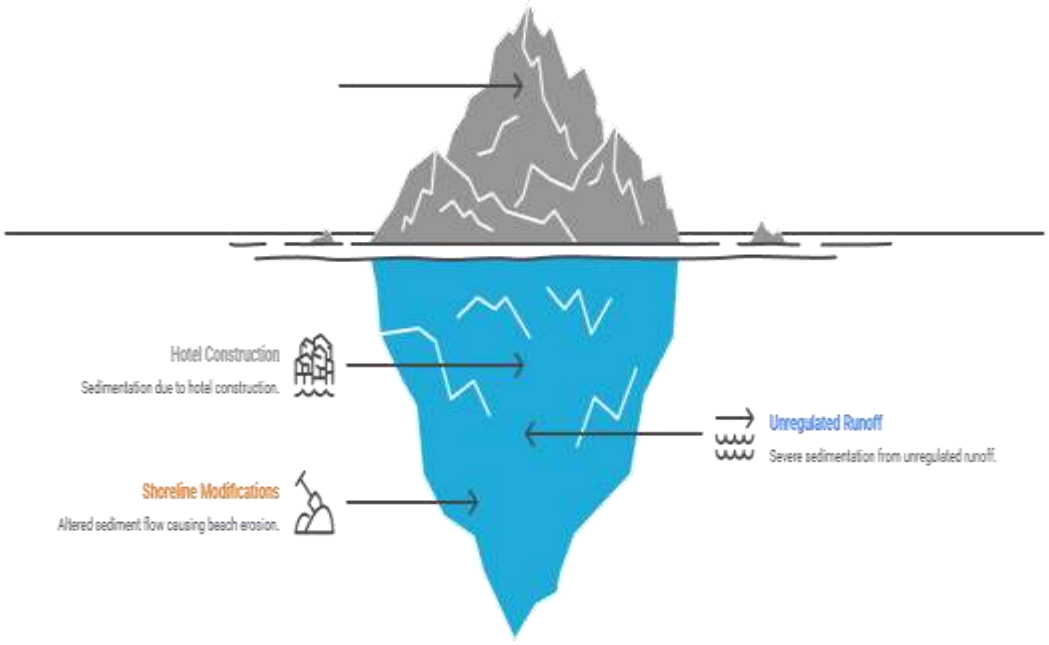

Figure 1. Tourism's Hidden Environmental Costs in Jimbaran Bay

In contrast, Nusa Dua, managed under the Bali Tourism Development Corporation (BTDC), demonstrates a more balanced model. Strict zoning regulations and waste treatment facilities have maintained better water quality and coral cover. The contrasting outcomes between Jimbaran and Nusa Dua illustrate the role of institutional governance and sustainable management in mitigating tourism's environmental impacts.

The comparative findings indicate that coastal degradation is not an inevitable consequence of tourism development but a result of weak spatial planning and environmental oversight. Regions with coordinated management frameworks, environmental monitoring, and stakeholder participation show higher ecological stability. The integration of green infrastructure and eco-certification programs in tourism operations can significantly mitigate ecosystem degradation.

The role of education and environmental awareness is also evident. Communities engaged in coastal conservation projects demonstrate better compliance with waste management and reef protection practices. This suggests that capacity building and environmental education are critical components in achieving sustainable coastal tourism, reinforcing the link between education, policy, and ecological resilience.

The overall results demonstrate a strong causal connection between the intensity of tourism development and the degradation of southern Bali's coastal ecosystems. Rapid infrastructure expansion, combined with insufficient environmental regulation, has led to habitat loss, declining biodiversity, and worsening water quality. However, examples of managed zones such as Nusa Dua prove that sustainable tourism is achievable when ecological considerations are integrated into spatial planning and governance frameworks.

The interpretation underscores the importance of adopting a sustainability-based educational framework in tourism policy. Awareness, regulation, and community engagement are key determinants in balancing economic growth with ecological preservation. The study affirms that coastal ecosystems are not merely passive victims of tourism but can become active assets for sustainable development when managed through participatory and environmentally literate approaches.

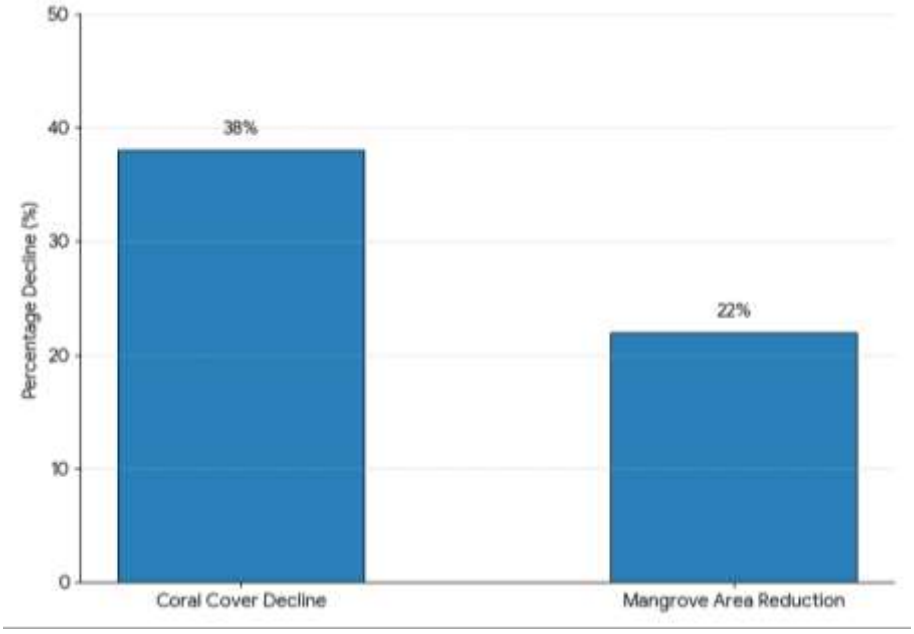

Figure 2. Environmental Degradation In Southern Bali

The findings confirm that tourism development in southern Bali has intensified environmental degradation along the coastline. Spatial and statistical analyses reveal a 38% decline in coral cover,

a 22% reduction in mangrove areas, and rising water pollution levels over the past decade. These results indicate a direct correlation between infrastructure expansion and ecosystem degradation. Qualitative data further suggest that ineffective environmental regulation and limited community awareness have accelerated this decline. The imbalance between economic growth and ecological preservation has become a defining feature of Bali's tourism landscape.

The analysis highlights that areas under structured management, such as Nusa Dua, maintain relatively stable ecosystem health compared to unregulated zones like Kuta and Jimbaran. Communities actively involved in waste management and coastal rehabilitation demonstrate higher environmental resilience (Sun dkk., 2024). The combination of quantitative and qualitative evidence establishes a comprehensive picture: tourism development, if unmanaged, leads to measurable ecological deterioration, while governance and education can mitigate negative impacts.

The results are consistent with global studies that link mass tourism to coastal ecosystem decline, such as Hall (2019) and Gössling (2020), who emphasized how rapid tourism growth exerts unsustainable pressure on fragile environments. Similar patterns have been observed in Thailand's Phuket and the Philippines' Boracay, where tourism-driven land conversion led to coral and mangrove degradation. This study contributes to the discourse by providing spatial and socio-environmental data specific to Bali, offering localized evidence of global environmental dynamics.

A key distinction emerges from the integration of educational and participatory dimensions in this research (Mashula dkk., 2025). While previous studies often focus on economic and ecological indicators, this study incorporates community learning and policy awareness as mediating factors. The inclusion of education as an analytical variable enriches understanding of how human agency, environmental literacy, and governance interplay in sustaining or degrading ecosystems. The difference underscores that ecological restoration is not merely technical but behavioral and cultural.

The findings signify that Bali's environmental crisis is not only ecological but also structural, rooted in governance inefficiency and socio-cultural adaptation. The pattern of degradation reflects a systemic disconnect between environmental policy and local implementation (Chukwuka dkk., 2025). The deterioration of coral reefs, mangroves, and coastal water quality signals a breakdown of natural resilience systems essential for both ecological balance and disaster mitigation.

The research further reveals a paradox of development: economic prosperity derived from tourism simultaneously erodes the very ecosystems that sustain it. This duality serves as a warning sign for other developing regions dependent on nature-based tourism. The results indicate that without integrated environmental education, community participation, and strict policy enforcement, Bali's model of growth remains ecologically unsustainable.

The implications of these findings extend to policy, education, and practice. Policymakers must reassess tourism zoning regulations, enforce coastal setback rules, and establish stronger waste management systems to prevent irreversible environmental loss (Schuhbauer dkk., 2025). The data suggest that integrating green infrastructure such as constructed wetlands and eco-friendly sewage treatment can mitigate environmental pressure while maintaining tourism viability.

From an educational perspective, the findings highlight the necessity of embedding environmental literacy into community and school programs. Raising awareness among residents, entrepreneurs, and tourists can foster a shared sense of ecological responsibility (Natasya & Nugroho, 2025). The study thus underscores that sustainable tourism depends not only on policy but also on the cultivation of environmental ethics and civic engagement at the grassroots level.

The primary cause of the observed degradation lies in unregulated development and weak enforcement of environmental regulations. Local governments often prioritize short-term economic gains from tourism investments, overlooking long-term ecological consequences (Nguyen dkk., 2025). The absence of clear coordination among tourism, environmental, and spatial planning agencies further exacerbates the issue. Bureaucratic overlap leads to inconsistent monitoring and fragmented accountability.

Cultural and behavioral factors also contribute to the results. Many local stakeholders perceive environmental protection as a government responsibility rather than a collective duty. Limited access to environmental education and participatory decision-making diminishes local ownership of sustainability initiatives (Munawir dkk., 2025). The combination of institutional weakness, economic dependency, and social disempowerment explains why Bali's environmental conditions have deteriorated despite numerous sustainability campaigns.

The results call for an urgent transition from reactive to preventive environmental governance. Integrating spatial planning with ecological monitoring and community education can create a more resilient coastal management framework. Future strategies should include the establishment of eco-tourism certification programs, community-based monitoring units, and adaptive management policies aligned with local cultural practices.

Further research is needed to develop interdisciplinary models that combine environmental science, behavioral education, and policy innovation. Expanding the temporal and spatial scope to include northern and eastern Bali could reveal comparative patterns and scalability of sustainable interventions. The next step involves turning evidence into action—transforming Bali's tourism system into a living laboratory of education-driven, ecosystem-centered, and community-empowered sustainability.

CONCLUSION

The most significant finding of this study is the identification of a quantifiable relationship between tourism development intensity and coastal ecosystem degradation in southern Bali, supported by spatial and ecological data. The research reveals a 38% decline in coral cover and a 22% reduction in mangrove area, directly linked to tourism infrastructure expansion between 2010 and 2023. This study differs from previous research by incorporating an integrative framework that connects geospatial analysis, environmental indicators, and community perceptions. The results highlight that environmental degradation is not solely the consequence of tourism activity, but also the result of weak environmental governance and insufficient educational engagement. The inclusion of environmental literacy and community participation as analytical variables represents a novel perspective, demonstrating that social learning processes play a decisive role in determining the sustainability of coastal ecosystems in high-tourism regions.

The research contributes conceptually by introducing the eco-socio-spatial model, which synthesizes environmental science, social behavior, and policy education into a single analytical framework. This model redefines the understanding of sustainable tourism by positioning education and governance as mediating forces between economic growth and ecological balance. Methodologically, the study advances the use of mixed-method geospatial analysis combining satellite imagery, statistical correlation, and thematic coding of stakeholder interviews to produce both empirical precision and contextual depth. The approach provides a transferable methodology for future sustainability studies that aim to connect spatial data with social learning outcomes. The

findings thus bridge an important academic gap between environmental management research and educational approaches to community-based sustainability.

The research is limited by its geographical focus on southern Bali and its temporal range from 2010 to 2023, which may not capture broader climatic and socio-political dynamics influencing environmental change. Data on marine biodiversity and waste discharge were constrained by inconsistent local monitoring practices, reducing the granularity of ecological measurement. Future research should expand longitudinally and cross-regionally to include northern and eastern Bali for comparative analysis. Interdisciplinary studies integrating environmental education, policy intervention, and digital monitoring systems are recommended to assess the long-term effectiveness of sustainability measures. The next stage of inquiry should also examine the role of curriculum design and public participation programs in shaping community-driven conservation practices, transforming Bali's coastal management into a model of education-based ecological governance.

AUTHORS' CONTRIBUTION

Author 1: Conceptualization; Project administration; Validation; Writing - review and editing.
Author 2: Conceptualization; Data curation; In-vestigation.
Author 3: Data curation; Investigation.

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