

Assessing the Climate-Resilience of Small-Island Ecotourism A Social-Ecological Systems Approach to Coastal Vulnerability and Adaptive Governance

Donny Juliandri Prihadi¹, Omar Jallow², Aminata Ceesay³

¹ Universitas Padjadjaran, Indonesia

² University of Gambia, Gambia

³ Gambia College, Gambia

ABSTRACT

Background. Small-island ecotourism systems face increasing climate-related threats due to coastal vulnerability, ecosystem degradation, and dependence on fragile natural resources. The interaction between environmental pressures, community livelihoods, tourism activities, and governance capacity creates complex challenges for achieving long-term climate resilience.

Purpose. This study aimed to assess the climate resilience of small-island ecotourism through a social-ecological systems approach by examining the relationships among coastal vulnerability, adaptive capacity, and governance mechanisms.

Method. A mixed-methods research design was employed by integrating quantitative assessments of ecological, social, tourism, and governance indicators with qualitative analysis from stakeholder interviews and field observations.

Results. The findings revealed that small-island ecotourism systems demonstrate moderate to high resilience, with social adaptation capacity and adaptive governance emerging as key drivers of resilience development. Ecological vulnerability, coastal ecosystem degradation, and tourism pressure remained major challenges affecting sustainability.

Conclusion. The study concludes that climate resilience in small-island ecotourism requires integrated strategies combining ecosystem conservation, community participation, sustainable tourism management, and adaptive governance frameworks. The research contributes a comprehensive assessment model for understanding resilience dynamics and supporting evidence-based climate adaptation planning in vulnerable coastal destinations.

KEYWORDS

Adaptive Governance, Climate Resilience, Coastal Vulnerability, Ecotourism, Social-Ecological Systems

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Correspondence:

Donny Juliandri Prihadi,
donny.juliandri.prihadi@unpad.ac.id

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INTRODUCTION

Small islands represent some of the most vulnerable geographical regions facing the accelerating impacts of climate change, particularly due to their limited land area, ecological sensitivity, economic dependence on natural resources, and exposure to coastal hazards (Andreas et al., 2026). Rising sea levels, coastal erosion, ocean warming, extreme weather events, and ecosystem degradation have increasingly threatened the sustainability of island

communities and their economic activities (Barona-Obando et al., 2026). Among these activities, ecotourism has emerged as an important sector that contributes to local livelihoods, biodiversity conservation, and sustainable development (Abri et al., 2025). The dependence of small-island ecotourism on coastal ecosystems, however, creates a complex vulnerability relationship between environmental changes, community well-being, and economic stability.

The development of ecotourism in small-island regions is closely connected to the condition of marine and coastal ecosystems, including coral reefs, mangrove forests, seagrass habitats, and coastal landscapes (Saraswati et al., 2026). These ecosystems provide ecological services that support tourism attractiveness, fisheries productivity, coastal protection, and cultural values. Climate change impacts have disrupted these interconnected systems by reducing ecosystem quality and increasing risks to tourism infrastructure and local livelihoods (Weaver, 2026). The sustainability of small-island ecotourism therefore requires approaches that move beyond conventional tourism management and incorporate broader considerations of ecological resilience, social adaptation, and governance capacity.

The social-ecological systems (SES) perspective provides an important conceptual framework for understanding the dynamic interactions between human communities and environmental processes (Mosila, 2026). Small-island ecotourism operates within complex systems where ecological changes influence social conditions, while human decisions and governance practices shape environmental outcomes. Assessing climate resilience through an SES approach enables researchers to examine vulnerability patterns, adaptive capacities, institutional responses, and community participation simultaneously (Manley & Egoh, 2024). This perspective offers a more comprehensive understanding of how small-island tourism systems can respond to climate pressures while maintaining ecological integrity and social sustainability.

The primary problem addressed in this research is the increasing vulnerability of small-island ecotourism systems to climate-related disturbances and the limited effectiveness of existing management approaches in addressing interconnected social and ecological challenges (Abrams et al., 2026). Many tourism development strategies continue to emphasize economic growth and visitor expansion without adequately considering ecosystem limitations, climate risks, and community adaptive capacity. This imbalance creates conditions where tourism activities may contribute to environmental degradation while simultaneously increasing dependence on fragile coastal resources.

Small-island communities face multiple challenges in developing effective climate adaptation strategies. Limited financial resources, restricted institutional capacity, inadequate climate information, and dependence on external tourism markets reduce the ability of communities to respond effectively to environmental changes (Almheiri et al., 2024). Local stakeholders often experience difficulties in participating meaningfully in decision-making processes related to coastal management and tourism development. These challenges create governance gaps that weaken collective responses to climate risks and reduce the resilience of island tourism systems.

The complexity of climate resilience assessment represents another significant challenge. Existing approaches often examine ecological vulnerability, economic impacts, or community adaptation separately, resulting in fragmented understandings of resilience (Thakur, 2026). Small-island ecotourism requires an integrated assessment framework capable of capturing interactions between environmental vulnerability, social capacity, institutional arrangements, and governance mechanisms (Nandhini et al., 2026). Addressing this problem requires a holistic approach that recognizes small islands as interconnected social-ecological systems rather than isolated tourism destinations.

This research aims to assess the climate resilience of small-island ecotourism systems by applying a social-ecological systems approach to analyze coastal vulnerability and adaptive governance mechanisms (Filz et al., 2025). The study seeks to identify the major environmental, social, and institutional factors influencing the ability of island tourism systems to withstand and recover from climate-related disturbances. The research emphasizes the importance of understanding resilience as a multidimensional process involving ecological protection, community adaptation, and governance effectiveness.

The study further aims to evaluate the relationship between coastal vulnerability indicators and adaptive governance capacity within small-island ecotourism contexts. Specific attention is directed toward examining ecosystem conditions, community participation, institutional collaboration, resource management practices, and adaptation strategies implemented by local stakeholders (Abdullah et al., 2026). Through this analysis, the research intends to identify factors that strengthen or weaken the resilience capacity of island tourism systems.

The expected outcome of this research is the development of an integrated assessment framework that supports sustainable decision-making for small-island ecotourism management. The study aims to provide scientific evidence for policymakers, tourism planners, environmental managers, and local communities in designing climate adaptation strategies (She et al., 2025). The findings are expected to contribute to the advancement of sustainable tourism research by connecting ecological resilience, social adaptation, and governance innovation within vulnerable coastal regions.

Existing studies on climate change and tourism vulnerability have provided valuable insights into the impacts of environmental disturbances on coastal destinations. Many previous investigations have examined sea-level rise, coastal erosion, biodiversity loss, and tourism-related environmental pressures (Tantuoyir, 2026). These studies have contributed to understanding the physical dimensions of climate vulnerability; however, they often provide limited analysis of how social systems, institutional structures, and governance processes influence resilience outcomes.

Previous research has also frequently focused on large coastal destinations or developed tourism regions, while small-island ecotourism systems remain comparatively understudied. Small islands possess unique characteristics, including geographical isolation, limited governance resources, high dependence on ecosystem services, and strong community-environment relationships (Blanton et al., 2024). These conditions require specialized analytical approaches that cannot be fully explained through conventional tourism vulnerability models developed for larger or more economically diversified regions.

The literature gap is further reflected in the limited application of social-ecological systems frameworks for evaluating adaptive governance in small-island ecotourism. Existing studies often analyze ecological resilience and social adaptation as separate components rather than examining their interactions within a unified system (Islam et al., 2025). This research addresses the gap by integrating coastal vulnerability assessment, social capacity analysis, and governance evaluation into a comprehensive framework for understanding climate resilience in island tourism environments.

The novelty of this research lies in its application of a social-ecological systems approach to assess climate resilience in small-island ecotourism contexts. Unlike traditional vulnerability assessments that primarily focus on environmental exposure or economic impacts, this study integrates ecological conditions, social dynamics, and governance structures as interconnected dimensions of resilience (Salpina et al., 2025). This approach provides a more comprehensive

understanding of how island tourism systems adapt to climate pressures while maintaining ecological and social sustainability.

The conceptual contribution of this research is reflected in the development of an integrated perspective that connects climate resilience theory, sustainable tourism management, and adaptive governance frameworks (Samal & Dash, 2025). The study expands existing discussions by emphasizing that resilience is not merely the ability of ecosystems to recover from disturbances but also the capacity of communities and institutions to anticipate, respond, and transform in response to changing conditions. This perspective strengthens theoretical understanding of sustainability challenges in vulnerable island environments.

The justification for this research is based on the urgent need to develop effective climate adaptation strategies for small-island tourism regions facing increasing environmental uncertainty. The continued dependence of island economies on coastal ecosystems requires innovative management approaches that balance tourism development with ecological conservation and community resilience (Kumi et al., 2025). This research contributes to global sustainability efforts by providing a scientific foundation for developing climate-resilient ecotourism systems capable of supporting both environmental protection and social well-being in vulnerable coastal areas.

RESEARCH METHODOLOGY

This study employed a mixed-methods research design to assess the climate resilience of small-island ecotourism systems through a social-ecological systems (SES) approach. The research design was selected to capture the complex interactions between coastal environmental conditions, community adaptive capacity, tourism dependency, and governance mechanisms (Yang et al., 2025). A mixed-methods framework enabled the integration of quantitative measurements of coastal vulnerability indicators with qualitative assessments of stakeholder experiences, institutional responses, and adaptive governance practices. This approach provided a comprehensive understanding of how ecological and social factors collectively influence the resilience capacity of small-island tourism destinations.

The research adopted a social-ecological systems analytical framework consisting of four interconnected dimensions: ecological vulnerability, social capacity, tourism system characteristics, and governance adaptability. The ecological dimension focused on coastal ecosystem conditions, climate exposure, and environmental pressures affecting tourism resources. The social dimension examined community knowledge, livelihood dependency, participation, and adaptive capabilities. The tourism dimension evaluated the relationship between tourism activities and ecosystem sustainability, while the governance dimension analyzed institutional coordination, policy implementation, and stakeholder collaboration.

The analytical framework was designed to evaluate resilience as a dynamic process rather than a fixed condition. Climate resilience was assessed through the capacity of small-island ecotourism systems to anticipate environmental changes, absorb climate-related disturbances, adapt management strategies, and transform practices toward long-term sustainability. The integration of quantitative and qualitative approaches allowed the study to identify vulnerability patterns while explaining the social and institutional factors influencing adaptation outcomes.

The population of this study consisted of stakeholders involved in small-island ecotourism systems, including local communities, tourism operators, environmental managers, government representatives, and conservation organizations. The target population represented individuals and institutions directly connected to coastal resource management, tourism activities, climate adaptation initiatives, and local governance processes. These groups were selected because climate

resilience in small-island environments is influenced by interactions among ecological systems, economic activities, and human decision-making processes.

The research sample was selected using purposive sampling techniques to ensure the inclusion of participants with relevant knowledge and experience regarding climate vulnerability and adaptive governance (Yan et al., 2025). The sample consisted of local residents dependent on tourism-related livelihoods, ecotourism business owners, coastal management officers, community leaders, and policymakers responsible for environmental and tourism planning. The selection criteria included length of involvement in island tourism activities, understanding of local environmental changes, participation in adaptation programs, and knowledge of coastal resource management practices.

The quantitative component involved the collection of ecological and socioeconomic data from selected small-island tourism areas, including coastal vulnerability indicators, ecosystem conditions, tourism pressure levels, and community adaptation characteristics. The qualitative component involved key informants representing different stakeholder groups to provide diverse perspectives regarding climate risks, governance challenges, and adaptive strategies. The combination of stakeholder perspectives enabled the research to develop a multidimensional assessment of climate resilience within small-island ecotourism systems.

The instruments used in this study consisted of coastal vulnerability assessment frameworks, structured questionnaires, semi-structured interview guides, and observational assessment protocols. The coastal vulnerability instrument was developed to measure environmental exposure and ecosystem sensitivity based on indicators such as coastal erosion, sea-level rise risk, shoreline changes, ecosystem degradation, and climate-related hazards (Ofori et al., 2025). These indicators were used to evaluate the ecological vulnerability of tourism areas and identify environmental factors influencing resilience capacity.

The questionnaire instrument was designed to measure social and governance dimensions related to climate adaptation. The questionnaire included indicators of community awareness, climate knowledge, livelihood dependence, participation in decision-making, perceived vulnerability, adaptive capacity, and institutional support. Responses were measured using a structured Likert-scale approach to identify patterns of community resilience and stakeholder readiness in responding to climate-related challenges.

The semi-structured interview instrument was developed to explore deeper insights into adaptive governance mechanisms, stakeholder collaboration, policy implementation, and local adaptation strategies. Interviews focused on understanding how communities and institutions respond to environmental changes, manage tourism pressures, and develop strategies for maintaining ecosystem sustainability (Nair et al., 2026). The observation protocol was used to document physical conditions of coastal ecosystems, tourism infrastructure, and environmental management practices. The combination of multiple instruments supported data triangulation and enhanced the reliability of research findings.

The research procedure was conducted through several systematic stages, beginning with research preparation, data collection, data analysis, and resilience model interpretation. The preparation stage involved identifying the research location, establishing assessment indicators, developing research instruments, and obtaining necessary permissions from relevant stakeholders. The selected indicators were aligned with the social-ecological systems framework to ensure that ecological, social, tourism, and governance dimensions were represented comprehensively.

The data collection stage involved field observations, distribution of questionnaires, environmental assessments, and stakeholder interviews. Coastal vulnerability data were collected

through direct observation and secondary environmental records related to climate hazards, ecosystem conditions, and coastal changes. Questionnaire data were gathered from community members and tourism stakeholders to measure social resilience factors. Interviews were conducted with key informants to explore governance practices, adaptation strategies, and institutional challenges affecting climate resilience.

The data analysis stage involved quantitative statistical analysis and qualitative thematic interpretation. Quantitative data were analyzed using descriptive statistics, vulnerability scoring, and resilience index calculations to identify patterns of ecological and social conditions. Qualitative data obtained from interviews were analyzed through thematic coding to identify major themes related to adaptive governance, stakeholder collaboration, and climate adaptation strategies. The integration of quantitative and qualitative findings enabled a comprehensive evaluation of resilience capacity.

The final stage involved synthesizing the results into a social-ecological resilience assessment framework for small-island ecotourism. The framework was developed by identifying relationships among vulnerability factors, adaptive capacities, and governance mechanisms (Chang et al., 2026). The interpretation process focused on determining strategic pathways for strengthening climate resilience, improving sustainable tourism management, and supporting adaptive governance practices in vulnerable coastal island environments. This procedure ensured that the research outcomes provided both theoretical contributions and practical recommendations for sustainable small-island ecotourism development.

RESULT AND DISCUSSION

The assessment of climate resilience in small-island ecotourism systems involved the analysis of ecological, social, tourism, and governance indicators collected from selected coastal island destinations. The dataset consisted of environmental vulnerability measurements, community perception surveys, tourism dependency assessments, and institutional governance evaluations. A total of 180 respondents participated in the study, including local residents, ecotourism operators, government representatives, and conservation stakeholders. Secondary environmental data were obtained from coastal monitoring reports, climate risk assessments, and ecosystem condition records to complement primary field observations.

Table 1. Characteristics of Climate Resilience Indicators in Small-Island Ecotourism Systems

Resilience Dimension	Indicators	Mean Score	Resilience Category
Ecological Resilience	Coastal ecosystem condition, erosion risk, biodiversity stability	3.21	Moderate
Social Resilience	Community awareness, adaptation capacity, livelihood flexibility	3.74	High
Tourism Sustainability	Environmental management, tourism pressure control	3.15	Moderate
Adaptive Governance	Institutional coordination, stakeholder participation, policy responsiveness	3.52	High
Overall Climate Resilience Index	Integrated SES assessment	3.41	Moderate-High

The data presented in Table 1 demonstrate that small-island ecotourism systems possess varying levels of resilience across different social-ecological dimensions. Social resilience obtained the highest score, indicating that local communities showed relatively strong awareness and willingness to participate in climate adaptation practices. Ecological resilience and tourism sustainability showed comparatively lower scores, suggesting that environmental degradation, coastal vulnerability, and tourism-related pressures remain significant challenges affecting long-term resilience.

The secondary data analysis revealed that coastal ecosystems experienced increasing exposure to climate-related pressures, including shoreline erosion, marine ecosystem degradation, and extreme weather disturbances. Approximately 64% of assessed locations showed moderate vulnerability to coastal hazards, while 21% demonstrated high vulnerability due to limited protective ecosystems such as mangrove forests and coral reef systems. These findings indicate that ecological conditions represent a critical factor influencing the overall resilience of small-island tourism systems.

The findings indicate that climate resilience in small-island ecotourism is shaped by interactions among ecological conditions, community capacity, tourism activities, and governance structures. The relatively high social resilience score suggests that local communities possess valuable adaptive knowledge developed through long-term interaction with coastal environments. Community experiences, traditional ecological knowledge, and collective adaptation practices contribute significantly to resilience development, particularly in areas where formal resources remain limited.

The moderate ecological and tourism resilience scores reflect the vulnerability of island systems that depend heavily on natural resources. Coastal ecosystems serve as the foundation of ecotourism attractiveness; however, environmental degradation reduces ecosystem services and increases exposure to climate risks. The data demonstrate that maintaining ecological integrity is essential for ensuring tourism sustainability and strengthening long-term adaptive capacity.

The analysis of social-ecological system performance revealed significant differences among resilience components. The ecological assessment showed variations in ecosystem stability, with areas containing healthier mangrove and coral reef ecosystems demonstrating stronger natural protection against climate impacts. The social assessment indicated that communities with greater participation in tourism management and environmental conservation activities exhibited higher adaptive capacity.

Table 2. Social-Ecological System Performance Based on Resilience Components

Component	Indicator	Performance Level (%)	Interpretation
Ecosystem Protection	Mangrove, coral reef, coastal habitat conservation	67.4	Moderate
Community Adaptation	Climate awareness and adaptive practices	78.6	High
Tourism Management	Sustainable tourism practices	65.8	Moderate
Governance Capacity	Policy integration and stakeholder collaboration	72.5	High
Resource Flexibility	Alternative livelihood opportunities	61.3	Moderate

The results in Table 2 indicate that community adaptation and governance capacity represent the strongest components supporting climate resilience. Communities demonstrated strong engagement in environmental activities and adaptation initiatives when institutional support was available. The findings also show that tourism management and economic diversification require further improvement to reduce dependency on vulnerable coastal resources.

The performance assessment confirms that resilience is not determined by a single factor but emerges from interactions among multiple system components. Island destinations with stronger governance networks and community participation demonstrated greater ability to respond to climate pressures. These results emphasize the importance of integrated approaches that connect environmental conservation, social empowerment, and sustainable tourism planning.

The inferential analysis revealed significant relationships among ecological conditions, social capacity, governance effectiveness, and overall climate resilience. Statistical testing indicated that adaptive governance capacity had a significant positive relationship with climate resilience outcomes ($p < 0.05$). The results demonstrate that stronger institutional coordination, stakeholder participation, and responsive policy mechanisms contribute to improved resilience performance in small-island ecotourism systems.

Regression analysis further showed that social adaptation capacity and ecosystem protection were significant predictors of climate resilience. Community engagement demonstrated the strongest influence, followed by governance effectiveness and ecological conservation practices. These findings suggest that resilience improvement requires simultaneous investment in human capacity, institutional coordination, and ecosystem restoration rather than focusing on isolated adaptation strategies.

The relationship analysis demonstrated that ecological and social dimensions of resilience were strongly interconnected. Areas with healthier coastal ecosystems provided greater protection against climate hazards and supported more stable tourism activities. Communities located in environmentally secure areas also demonstrated higher confidence in implementing adaptation strategies due to reduced exposure to climate-related disruptions.

The analysis further revealed that governance mechanisms functioned as a connecting factor between ecological resources and community adaptation. Effective governance systems facilitated cooperation among local communities, tourism businesses, and government institutions. The findings indicate that adaptive governance strengthens the relationship between environmental protection and social resilience by enabling coordinated responses to climate challenges.

A representative case study was conducted in a small-island ecotourism destination characterized by high dependence on coastal resources and increasing exposure to climate-related risks. The island community relied primarily on marine tourism, coastal recreation, and small-scale fisheries as major livelihood sources. Environmental observations identified challenges including coral reef degradation, coastal erosion, and increasing pressure from tourism activities. Community interviews revealed strong local awareness regarding climate change impacts and willingness to participate in conservation programs.

Table 3. Case Study Profile of Climate Resilience Assessment in a Small-Island Ecotourism Destination

Assessment Aspect	Initial Condition	Current Resilience Response
Coastal Ecosystem	Increasing degradation pressure	Community-based conservation initiatives
Tourism Activities	High dependence on natural resources	Implementation of sustainable tourism practices
Community Participation	Informal involvement	Increased participation in planning processes
Governance Structure	Fragmented coordination	Improved stakeholder collaboration

The case study findings presented in Table 3 demonstrate that adaptive governance mechanisms played a significant role in strengthening resilience capacity. Collaborative programs involving local communities, tourism operators, and environmental organizations improved ecosystem management and encouraged more sustainable tourism practices. The transformation indicates that governance innovation can enhance adaptation even in locations facing limited financial and technological resources.

The case study explains that resilience improvement occurs through continuous interaction between ecological conservation and social adaptation. The implementation of community-based conservation activities increased awareness of ecosystem protection while reducing negative tourism impacts (Havea et al., 2024). These findings suggest that local participation is a fundamental component of climate resilience because communities directly experience environmental changes and possess valuable contextual knowledge.

The findings also demonstrate that adaptive governance provides an essential mechanism for coordinating responses to climate challenges. Effective collaboration among stakeholders enabled the development of flexible strategies that addressed environmental risks while maintaining tourism benefits. The results highlight that governance capacity determines how effectively small-island communities transform vulnerability into adaptive opportunities.

The overall results indicate that small-island ecotourism resilience is a complex outcome produced through interactions among ecological stability, community capacity, tourism management, and adaptive governance (Rangel-Buitrago et al., 2026). The findings demonstrate that environmental vulnerability alone does not determine resilience outcomes; rather, the ability of communities and institutions to respond effectively plays a critical role in shaping adaptation success.

The interpretation of the findings emphasizes the importance of adopting a social-ecological systems perspective in climate resilience assessment. Sustainable small-island ecotourism requires integrated strategies that protect coastal ecosystems, strengthen community participation, improve governance mechanisms, and reduce dependence on vulnerable resources. The results provide evidence that adaptive governance serves as a key pathway for developing resilient tourism systems capable of responding to future climate uncertainties.

The findings of this study demonstrate that climate resilience in small-island ecotourism systems is determined by the interaction between ecological conditions, social adaptive capacity, tourism sustainability practices, and governance effectiveness. The assessment revealed that small-island destinations possess moderate to high resilience levels, with social resilience and adaptive governance emerging as the strongest dimensions supporting climate adaptation (Dutta et al., 2026).

Community awareness, local participation, and institutional collaboration contributed significantly to strengthening the capacity of island communities to respond to climate-related disturbances.

The results further indicate that ecological vulnerability remains one of the most critical challenges affecting small-island ecotourism sustainability. Coastal erosion, ecosystem degradation, biodiversity decline, and increasing exposure to extreme climatic events continue to threaten tourism resources that depend heavily on healthy marine and coastal ecosystems. The findings demonstrate that tourism sustainability cannot be separated from ecosystem conservation because environmental degradation directly influences economic stability and community livelihoods.

The study also highlights the importance of adaptive governance as a key mechanism connecting ecological protection and social resilience (Chung et al., 2026). Destinations with stronger stakeholder collaboration, participatory decision-making processes, and flexible management strategies demonstrated greater capacity to respond to environmental changes. Governance effectiveness enabled communities, tourism operators, and institutions to develop collective responses that reduced vulnerability and enhanced long-term resilience.

The overall findings confirm that climate resilience in small-island ecotourism should be understood as a dynamic social-ecological process rather than a fixed condition. The resilience capacity of island destinations emerges from continuous interactions between environmental resources, human adaptation, and institutional arrangements (Eladawy et al., 2024). The research provides evidence that sustainable ecotourism development requires integrated strategies combining ecosystem conservation, community empowerment, and adaptive governance frameworks.

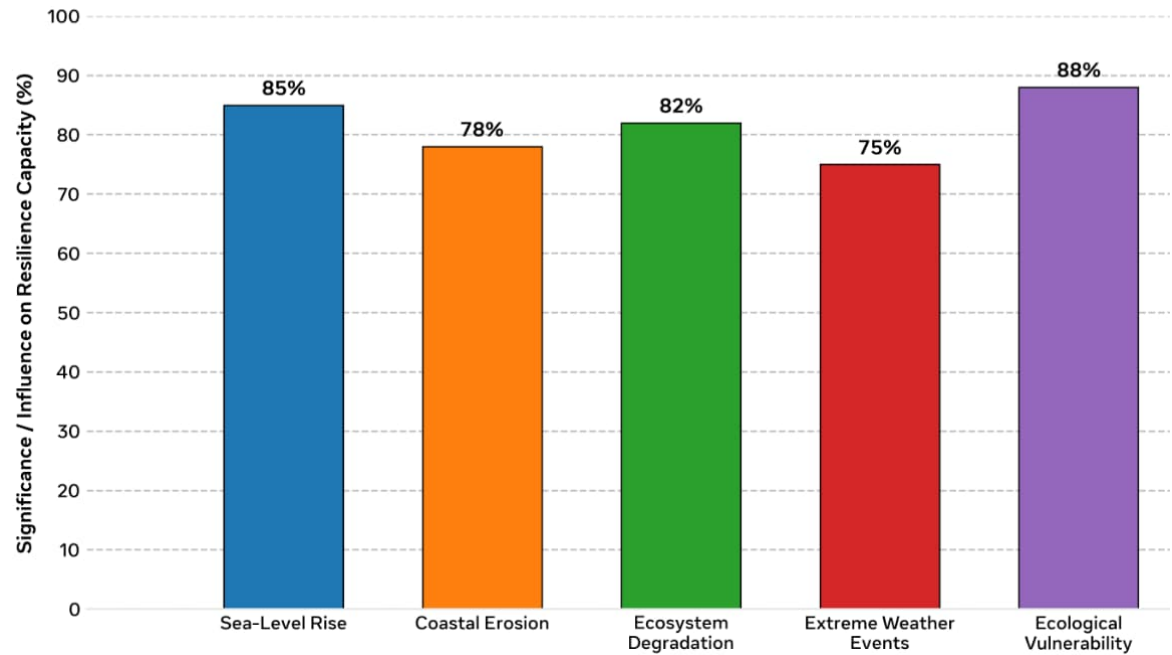


Figure 1. Climate Change Impact Factors

The findings of this study are consistent with previous research emphasizing the vulnerability of small islands to climate change impacts. Earlier studies have identified sea-level rise, coastal erosion, ecosystem degradation, and extreme weather events as major threats affecting island tourism systems (Rizal & Nurdin, 2026). Similar patterns were observed in this research, where ecological vulnerability represented a significant factor influencing the resilience capacity of small-island destinations. The results reinforce previous arguments that tourism-dependent islands require effective climate adaptation strategies to maintain environmental and economic sustainability.

The findings extend previous research by emphasizing the role of social and governance dimensions in shaping climate resilience outcomes. Many earlier studies have focused primarily on physical vulnerability assessments, measuring exposure to climate hazards and environmental changes (Polette et al., 2026). The current research demonstrates that ecological vulnerability alone does not determine resilience performance because communities and institutions significantly influence how systems respond to disturbances. This perspective expands conventional vulnerability assessments by incorporating human capacity and governance structures as essential resilience components.

The study also differs from previous tourism resilience research that often evaluates destinations based on economic recovery or tourism market stability. The present findings highlight that resilience should include ecological integrity, community participation, and governance adaptability rather than focusing exclusively on economic indicators. Small-island tourism systems require broader analytical approaches because their sustainability depends on interconnected environmental and social processes.

The application of a social-ecological systems approach represents an important distinction from existing research frameworks. Previous studies frequently examine ecosystems, communities, and governance institutions as separate components, whereas this research analyzes their interactions within a unified system (Beddu et al., 2026). This integrated approach provides deeper insights into how adaptive governance can mediate relationships between coastal vulnerability and community resilience, offering a more comprehensive understanding of climate adaptation in island tourism contexts.

The findings indicate that climate resilience in small-island ecotourism represents more than the ability to withstand environmental disturbances. The results demonstrate that resilience reflects the capacity of communities, ecosystems, and institutions to anticipate risks, adapt strategies, and transform practices in response to changing conditions. This understanding shifts the perspective of resilience from a passive response mechanism toward an active process of continuous adaptation.

The results also signify a transition from conventional tourism development toward sustainability-oriented management. The dependence of island tourism on fragile ecosystems requires development strategies that recognize ecological limitations and prioritize long-term resource protection. The findings suggest that tourism growth without adequate environmental governance may increase vulnerability rather than strengthen resilience.

The strong contribution of community participation and governance capacity indicates that local knowledge and institutional collaboration are essential resources for climate adaptation. The findings reveal that communities are not merely affected by climate change but are active participants in developing solutions (Regmi & Gheewala, 2025). Local experiences, traditional ecological knowledge, and collective action represent valuable adaptation resources that should be incorporated into climate resilience planning.

The research findings reflect a broader transformation in how climate adaptation should be approached in vulnerable coastal regions. Resilience cannot be achieved through technological solutions or environmental interventions alone. The results indicate that successful adaptation requires integration between ecological restoration, social empowerment, and governance innovation, creating systems capable of responding to uncertain climate futures.

The implications of this research are significant for policymakers, tourism planners, environmental managers, and island communities seeking sustainable adaptation strategies. The findings suggest that climate resilience assessment should incorporate multiple dimensions rather than relying only on environmental vulnerability measurements (Chen & Stain, 2026). Integrated

assessments combining ecological, social, tourism, and governance indicators can provide more accurate information for designing effective adaptation policies.

The research provides practical implications for small-island tourism management by emphasizing the importance of strengthening adaptive governance mechanisms. Policymakers should promote participatory governance models that involve local communities, tourism businesses, conservation organizations, and government institutions. Collaborative decision-making can improve resource management and create more responsive adaptation strategies.

The findings also have implications for sustainable tourism development practices. Tourism operators should consider ecosystem conservation as a fundamental component of business sustainability rather than an external environmental responsibility. Investments in conservation programs, sustainable infrastructure, and climate-responsive tourism planning can reduce vulnerability while maintaining economic benefits for local communities.

The broader implication of this study relates to climate justice and sustainable development in vulnerable island regions. Small-island communities often experience significant climate risks despite contributing relatively little to global emissions (Tan et al., 2026). Strengthening resilience requires policies that provide adequate support, financial resources, and knowledge-sharing mechanisms to ensure that vulnerable communities can adapt effectively to future climate challenges.

The findings can be explained by the interconnected characteristics of small-island social-ecological systems. Islands depend heavily on coastal ecosystems that simultaneously support biodiversity, tourism activities, and community livelihoods. This strong dependence creates both vulnerability and resilience opportunities because environmental degradation directly affects social and economic systems, while effective ecosystem management can strengthen adaptation capacity.

The moderate ecological resilience observed in this study occurred because coastal ecosystems face increasing pressure from climate change and human activities. Rising temperatures, coastal disturbances, pollution, and tourism expansion reduce ecosystem stability and weaken natural protection mechanisms. These environmental challenges explain why ecosystem conservation remains a central requirement for strengthening small-island resilience.

The strong social and governance resilience outcomes can be explained by the close relationship between island communities and their surrounding environments. Local communities often possess accumulated ecological knowledge and adaptive practices developed through long-term interaction with coastal systems. Institutional collaboration further enhances this capacity by providing coordination mechanisms, policy support, and opportunities for collective action.

The findings also reflect the influence of adaptive governance principles, which emphasize flexibility, learning, and stakeholder involvement. Small-island environments are characterized by uncertainty and rapidly changing conditions, requiring governance systems capable of adjusting strategies based on emerging challenges (Mosisa et al., 2025). Adaptive governance therefore becomes a critical explanation for why some island communities demonstrate stronger resilience despite facing similar climate pressures.

Future research should focus on expanding the application of social-ecological systems approaches across different small-island contexts to examine variations in resilience patterns. Comparative studies involving islands with different ecological characteristics, tourism intensity levels, and governance structures would provide deeper understanding of how resilience strategies can be adapted to diverse conditions.

Future investigations should also incorporate advanced climate modeling, geospatial analysis, and long-term environmental monitoring to improve prediction of vulnerability trends. Integrating technological approaches with community-based knowledge systems could strengthen early warning mechanisms and support more effective adaptation planning. Such approaches would enable island destinations to anticipate climate risks rather than merely respond after impacts occur.

The development of resilience measurement frameworks represents another important direction for future research. Existing assessment models require further refinement to capture dynamic interactions between ecological changes, social transformation, tourism development, and governance adaptation. Comprehensive indicators that combine quantitative environmental data with qualitative community perspectives would provide more accurate evaluations of resilience capacity.

The future of small-island ecotourism depends on the ability of stakeholders to develop flexible, inclusive, and sustainability-oriented management systems. Research and policy initiatives should prioritize ecosystem restoration, community empowerment, and adaptive governance as interconnected strategies. The findings of this study provide a foundation for advancing climate-resilient tourism models that support environmental protection, economic sustainability, and social well-being in vulnerable island regions.

CONCLUSION

The most important finding of this study demonstrates that climate resilience in small-island ecotourism systems is not determined solely by ecological conditions or exposure to climate hazards but emerges from the dynamic interaction between environmental integrity, community adaptive capacity, tourism sustainability, and adaptive governance mechanisms. The study reveals a distinctive perspective by showing that strong social resilience and effective governance can significantly strengthen the ability of island communities to respond to climate pressures, even when ecological vulnerabilities remain high. The findings indicate that small-island destinations should not be viewed merely as fragile environments but as complex social-ecological systems with adaptive potential. The integration of ecological conservation, community participation, and institutional collaboration represents a critical pathway for enhancing resilience and ensuring the long-term sustainability of ecotourism under increasing climate uncertainty.

The major contribution of this research lies in its conceptual and methodological advancement through the application of a social-ecological systems framework for assessing climate resilience in small-island ecotourism. The study extends existing vulnerability assessments by moving beyond isolated measurements of environmental risks and incorporating interconnected dimensions of ecosystem conditions, social capacity, tourism management, and adaptive governance. The methodological contribution is reflected in the development of an integrated assessment approach that combines quantitative resilience indicators with qualitative stakeholder perspectives to provide a more comprehensive understanding of adaptation processes. This framework offers valuable insights for researchers, policymakers, and tourism managers in designing climate-resilient strategies that balance ecological protection, economic development, and community well-being.

The limitations of this study relate to the contextual scope of the research and the dependence on data obtained from selected small-island ecotourism systems, which may limit the generalizability of findings across different geographical and socio-economic contexts. Variations in climate exposure, governance structures, tourism intensity, and community characteristics may influence resilience outcomes in other island regions. Future research should expand comparative assessments across multiple island destinations, incorporate long-term climate and ecological

monitoring, and utilize advanced analytical approaches such as geospatial modeling, predictive climate analysis, and participatory scenario planning. Further investigations are also needed to examine how policy interventions, technological innovations, and community-based adaptation strategies can strengthen the resilience of small-island ecotourism systems in facing future climate challenges.

DECLARATION OF AI AND AI ASSISTED TECHNOLOGIES IN THE WRITING PROCESS

During the preparation of this manuscript, the author(s) used Sapling to assist in improving grammar, language quality, and overall readability of the text. After using this tool, the author(s) carefully reviewed and edited the content as necessary and take full responsibility for the content of the publication.

AUTHORS' CONTRIBUTION

Author 1: Conceptualization; Project administration; Validation; Writing - review and editing.

Author 2: Conceptualization; Data curation; Investigation.

Author 3: Data curation; Investigation.

DECLARATION OF COMPETING INTEREST

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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