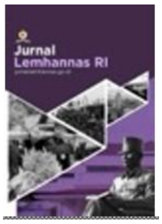

Jurnal Lemhannas RI (JLRI)
e-ISSN : 2830-5728
Vol. 13 No. 2, June 2025: 231-245
DOI: 10.55960/jlri.v13i2.1245
https://jurnal.lemhannas.go.id/index.php/jkl

Climate Change Mitigation and Disaster Preparedness in Indonesia's Outermost Islands

Nouldy Jan Tangka[1], Rido Hermawan[2*], Kup Yanto Setiyono[3], Andrea S. Pulungan[4]
[1] Indonesian Navy Headquarters, Indonesia
[2,3] Universitas Dian Nusantara, Jakarta, Indonesia
[4] Lembaga Ketahanan Republik Indonesia, Indonesia

(*) Corresponding Author: rido.hermawan@dosen.undira.ac.id

Article Info:

Keywords:
Climate change mitigation.
Disaster preparedness.
Governance.
National resilience.
Outermost islands.

Article History:
Received : 2-6-2025
Revised : 14-6-2025
Accepted : 30-6-2025

Article DOI :
10.55960/jlri.v13i2.1245

Abstract

Purpose: This study aims to analyse the governance of climate change responses on Indonesia's outermost islands, using Miangas Island as a strategic case study. The analysis evaluates the role of climate adaptation in strengthening disaster preparedness and national resilience amidst environmental threats and the vulnerabilities inherent to border regions.

Study Design/Methodology/Approach: A qualitative descriptive case study approach integrates document analysis, policy analysis, and a SWOT matrix. Baseline data, regulations, official reports, and international climate databases were analysed using socio-ecological systems theory, adaptive governance, the Sendai Framework, and the *Asta Gatra* model of national resilience. This framework encompasses *Tri Gatra* (natural aspects) and *Panca Gatra* (social aspects) as dimensions of national resilience.

Findings: Miangas faces biophysical vulnerabilities due to its limited land area, low elevation, rising temperatures and sea levels, and coastal abrasion. Disaster preparedness is further constrained by a lack of integrated early warning systems and limitations regarding evacuation infrastructure, trained personnel, and transportation access. The *Asta Gatra* analysis reveals that pressures on *Tri Gatra* can impact *Panca Gatra* by disrupting livelihoods, public services, population mobility, and border security. Social capital, the mapalus tradition, Miangas's strategic location, and policy support serve to strengthen the community's adaptive capacity.

Originality/Value: This article positions the outermost island as a strategic space that links climate adaptation, environmental resilience, disaster preparedness, territorial integrity, sovereignty, and national security within the *Asta Gatra* framework.

How to cite: Tangka, N.J., Hermawan, R., Setiyono, K.Y., Pulungan, A.S. (2025). Climate Change Mitigation and Disaster Preparedness in Indonesia's Outermost Islands. Jurnal Lemhannas RI, 13 (2), 231-245. https://doi.org/10.55960/jlri.v13i2.1245

e-ISSN: 2830-5728

INTRODUCTION

Climate change has emerged as a multidimensional strategic challenge that extends beyond environmental concerns to encompass economic stability, social cohesion, territorial governance, and national security. From a management and policy perspective, this challenge demands integrated governance frameworks that link climate risk reduction with disaster preparedness and border resilience. The Intergovernmental Panel on Climate Change (IPCC) documented that global surface temperatures have risen by approximately 1.1°C between 2011 and 2020 compared to the 1850-1900 average, driven primarily by anthropogenic greenhouse gas emissions (IPCC, 2023). Rising global temperatures are accelerating sea-level rise, altering precipitation patterns, and increasing the frequency and intensity of extreme weather events. These climate dynamics heighten the risk of hydrometeorological disasters, particularly in highly vulnerable regions. The World Meteorological Organization (WMO) has recorded 2024 as the hottest year in the last 175 years, with global average temperatures approximately 1.55°C above pre-industrial levels. This record-breaking heat has been accompanied by elevated sea-surface temperatures and increased ocean heat content, thereby intensifying pressures on coastal communities, island economies, and archipelagic nations (WMO, 2025).

From a governance and management perspective, disaster preparedness is viewed as a strategic institutional capacity that supports territorial integrity and national resilience. The Asian region faces high levels of risk due to rapid population growth, the concentration of economic activities in coastal areas, large-scale land-use changes, and infrastructure limitations and aging. This combination of factors heightens the exposure of communities and territories to increasingly intense climate-related hazards. The UN Office for Disaster Risk Reduction (UNDRR) estimates that the frequency of global disasters could rise from approximately 400 events per year in 2015 to 560 events by 2030 if current risk patterns persist without adequate mitigation efforts (UNDRR, 2022). These projections underscore the need to shift disaster governance from a reactive approach toward a more preventive and integrated strategy. Risk reduction, climate adaptation, spatial planning, social protection, and infrastructure development must be integrated into a unified development policy framework to prevent environmental hazards from escalating into disasters with widespread impacts. This imperative is particularly critical for archipelagic nations, where geographical dispersion, limited inter-island connectivity, high exposure to oceanic and atmospheric dynamics, and community reliance on coastal and marine resources compound the complexity of risk management.

Indonesia exemplifies the management and governance challenges posed by archipelagic climate vulnerability. The nation encompasses more than 17,000 islands, maintains an extensive coastline spanning thousands of kilometres, and exercises jurisdiction over marine areas of strategic and economic significance (BIG, 2022). While archipelagic geography confers advantages through access to marine resources, control of major trade corridors, and substantial geopolitical positioning, the dispersed configuration of island communities simultaneously constrains equitable infrastructure distribution, complicates public service delivery, limits the deployment of climate monitoring systems, and strains centralised disaster management capacity. Outermost and smaller islands face compounded challenges because geographic isolation restricts access to advanced technology, institutional support systems, and technical expertise, while communities' economic dependence on fisheries and coastal resources amplifies their vulnerability to environmental change. From a management standpoint, maintaining

e-ISSN: 2830-5728

institutional capacity, service continuity, and economic viability across these dispersed territories represents a distinct governance challenge requiring tailored institutional arrangements and locally adapted strategies.

Observable oceanographic changes underscore escalating climate pressures across the Indonesian archipelago and demand management attention. Copernicus Marine Service reanalysis data from 2005 to 2025 show fluctuations in sea surface temperature between 26.5°C and nearly 30°C, with notably increasing variability recently (Copernicus Marine Service, 2024). This thermal variability cascades through multiple management-relevant systems: oceanographic conditions that support fisheries productivity, marine biodiversity distribution patterns critical to food security, and coastal ecosystem stability that underpins both economic activity and natural hazard buffering capacity. Long-term observational records reveal persistent ocean warming across Indonesian waters, reflecting sustained temperature increases over decades that cumulatively degrade oceanographic processes, compress fisheries productivity, alter marine species distributions, and progressively weaken the coastal ecosystem resilience upon which archipelagic populations depend (IPCC, 2023; FAO, 2024). Figure 1 illustrates the spatial pattern of warming in sea surface temperature derived from the Copernicus Marine Service observational reanalysis for 1982–2024 (Copernicus Marine Service, 2024).

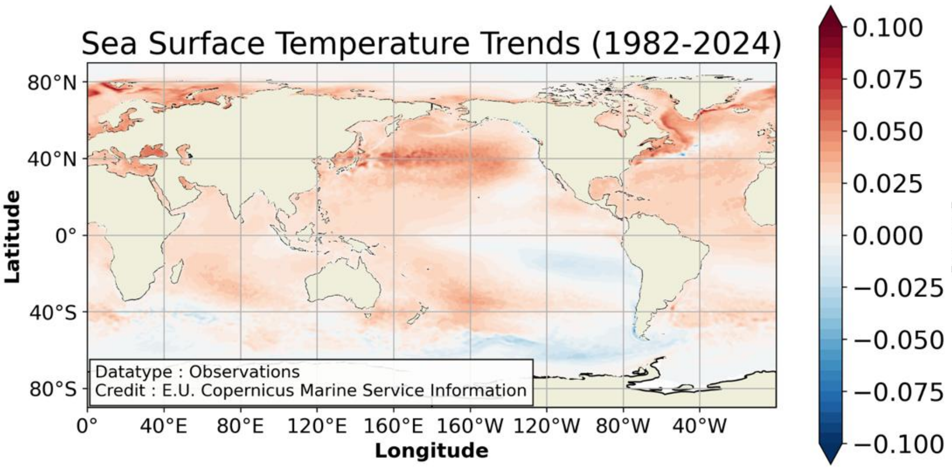

Figure 1. Long-term Sea Surface Temperature Trends across Indonesian Waters, 1982-2024
Source: Adapted from Copernicus Marine Service observational sea surface temperature reanalysis (SST-GLO-SST-L4-REP-OBSERVATIONS-010-024), 1982-2024

Beyond ecological dimensions, rising sea surface temperatures carry direct management and governance implications. Temperature increases alter fish stock distributions, contract fisheries productivity, accelerate coral ecosystem degradation, and disrupt established coastal livelihoods that sustain millions of households. These environmental transformations propagate through multiple institutional and economic channels: household income erosion, food security threats, elevated production costs, public health pressures, population displacement risks, and reduced governmental capacity to deliver essential services. From a systems perspective, climate change therefore constitutes a cascading risk multiplier for archipelagic states, as marine ecosystem degradation simultaneously undermines economic foundations, constrains

e-ISSN: 2830-5728

development prospects, and weakens state capacity to maintain territorial integrity and public service continuity in strategically significant border regions.

The *Asta Gatra* National Resilience Framework provides an integrative analytical lens for understanding these interconnections. Climate pressures directly affect the *Tri Gatra* dimensions comprising geography, natural resources, and population dynamics: sea-level rise and coastal erosion contract habitable territory, ecosystem degradation diminishes natural resource bases, and economic disruption triggers population mobility and settlement patterns. These primary effects subsequently propagate through *Panca Gatra* dimensions encompassing economic performance, political governance, socio-cultural cohesion, and defence and security functions (Lemhannas RI, 2022). Consequently, ecological vulnerability extends far beyond environmental concerns to directly engage national resilience, particularly across Indonesia's outermost border islands where state presence and institutional capacity require sustained investment.

The marine and fisheries sector's economic magnitude amplifies management imperatives for climate resilience. Indonesia's fisheries sector contributed 2.62% of national GDP, generated approximately IDR 417 trillion in economic value during 2022, provided employment for approximately 12.3 million individuals, encompassed roughly 2.7 million fishing households, and produced approximately 23.7 million tonnes of fishery output (BPS, 2023; KKP, 2022, 2023). This scale of economic interdependence means that climate-driven environmental degradation directly translates to household income losses, food security threats, increased operational expenses, and eroded livelihoods affecting millions of coastal residents. Indonesia's outermost islands demonstrate pronounced vulnerability within this system because adaptive infrastructure, technological capacity, and public service delivery systems remain comparatively constrained, thereby intensifying socio-economic management challenges for sustaining regional development trajectories and maintaining effective state presence across border territories.

Miangas Island is a strategically important example of how climate exposure, limited adaptive capacity, and national governance interests are all connected. Located at the northernmost extent of Talaud Islands Regency with direct adjacency to Philippine maritime space, Miangas covers approximately 3.15 km² and supports fewer than one thousand residents distributed across settlements vulnerable to climate impacts. The island's predominantly low-lying terrain, with elevations consistently below 10 metres above mean sea level creates acute exposure to multiple climate hazards, including sea-level rise, coastal flooding, shoreline erosion, extreme wave events, and weather-dependent transport disruptions. Observational data document that annual mean temperatures around Miangas increased from approximately 27.0°C to 27.6°C over the past two decades, while relative sea level rose at approximately 4.3 mm annually (BRIN, 2021). Concurrent shoreline erosion documented at 2–3 metres at several coastal locations within the past five years compounds management challenges by threatening settlements, public infrastructure, community activity spaces, and coastal ecosystem functions. From a governance perspective, these escalating pressures demand institutional responses that strengthen adaptive capacity, coordinate cross-sectoral action, and ensure service continuity.

The management-critical observation is that disaster preparedness and mitigation infrastructure have not evolved commensurate with rising climate risks. Miangas Island currently lacks integrated early warning systems, maintains inadequate permanent evacuation facilities, operates with insufficient emergency logistics capacity, and faces

e-ISSN: 2830-5728

critical human resource shortages in disaster management personnel. Weather-dependent sea and air transport frequently constrains personnel deployment, delays humanitarian assistance delivery, and disrupts healthcare service continuity during extreme events, thereby impairing institutional response effectiveness. From a management standpoint, narrowing the gap between climate exposure and institutional adaptive capacity requires coordinated advancement across multiple dimensions: more robust institutional arrangements, more effective risk communication systems, enhanced human resource capacity and technical expertise, closer cross-sectoral coordination mechanisms among government agencies, and expanded community preparedness. These enhancements are particularly critical because settlement continuity, public service delivery, and economic activity represent tangible expressions of Indonesia's state presence and institutional effectiveness across strategically significant border territories (BPS Talaud Islands Regency, 2022, 2023; BRIN, 2021).

LITERATURE REVIEW

Theoretical and Analytical Frameworks for Climate Resilience Governance

This research integrates three complementary theoretical frameworks that collectively provide a comprehensive lens for understanding climate-resilience governance in archipelagic systems. Social-Ecological Systems Theory (Ostrom, 2009) explicates the interdependencies between societal institutions, environmental systems, and human communities in determining regional sustainability outcomes. This framework is particularly germane to management analysis because it emphasises that institutional design, governance arrangements, and decision-making processes critically influence how societies respond to environmental change. The Disaster Risk Reduction Framework (UNDRR, 2022) conceptualises risk as an emergent property arising from dynamic interactions among hazard exposure, systemic vulnerability, adaptive capacity, and institutional readiness. This operationally focused framework highlights that disaster preparedness is not merely an emergency response function but an integral dimension of development policy and institutional capacity. The *Asta Gatra*-based National Resilience Framework (Lemhannas RI, 2022) provides a distinctly integrative analytical perspective by explicitly linking physical and environmental dimensions (*Tri Gatra*: geography, natural resources, and population) with governance and state capacity dimensions (*Panca Gatra*: ideology, politics, economics, socio-culture, defence and security). This framework is particularly valuable for government management and strategic planning because it demonstrates that climate pressures operating on physical systems directly propagate through governance systems, economic structures, and state capacity. Collectively, these frameworks enable analysis that extends beyond fragmented sectoral perspectives to examine how institutional arrangements, governance choices, and resource allocation decisions collectively determine resilience outcomes.

Empirical Evidence: Climate Vulnerability in Coastal and Island Regions

Extensive empirical research shows that coastal areas and small islands face severe climate vulnerability because of high environmental exposure and limited adaptive capacity. Adger (2006) explains that vulnerability results from the interaction of exposure, sensitivity and adaptive capacity. Exposure reflects the extent to which a system encounters climate hazards, sensitivity indicates its susceptibility to adverse

e-ISSN: 2830-5728

effects, and adaptive capacity refers to its ability to respond effectively. These dimensions have important management implications because similar climate hazards can produce different outcomes depending on institutional arrangements, economic resources, technological capabilities and community organisation. Barnett and Adger (2003) further show that small islands experience compounded vulnerability because of limited land resources, fiscal capacity, economic diversification and access to advanced technologies. Their dependence on fisheries, tourism and coastal ecosystem services also increases exposure to sea level rise, ocean warming, saline intrusion and extreme weather, which can disrupt livelihoods, threaten food security, reduce settlement viability and place pressure on essential public services. Trundle et al. (2019) demonstrate that effective climate adaptation in small island communities depends not only on environmental and technical measures but also on institutional capacity. Adequate early warning systems, accessible evacuation infrastructure, sustained adaptation financing and capable local institutions remain essential, particularly where geographic isolation restricts access to resources and services.

Regional and global climate assessments reinforce these empirical patterns. The IPCC (2023) projects intensifying coastal flooding, accelerated shoreline erosion, expanded drought zones, and progressive marine ecosystem degradation across Southeast Asian regions, while the WMO (2025) documents that continued temperature increases and elevated ocean heat content threaten regional food systems, public health infrastructure, critical economic sectors, and marine-dependent economies. Indonesia manifests many of these vulnerabilities across its archipelagic territory: numerous small islands continue to operate with limited sea and air transport connectivity, restricted access to advanced monitoring technology, constrained fiscal resources for adaptation investment, and fragmented disaster management capacity distributed unevenly across dispersed jurisdictions. The Badan Nasional Penanggulangan Bencana (BNPB, 2024) documents that hydrometeorological hazards (floods, storms, landslides) dominate Indonesia's national disaster profile, establishing the strategic importance of strengthening climate resilience and disaster preparedness across small island systems as core elements of the national strategy for reducing disaster risk. Miangas Island exemplifies these interacting vulnerability factors through the simultaneous presence of significant climate exposure (rising temperatures and sea levels), geographic isolation (constraint on technology and service delivery), pronounced dependence on coastal ecosystems and fisheries, and strategic border significance to national interests. The management challenge is acute because rising temperatures, accelerating sea-level rise, documented shoreline erosion, and weather-dependent transport disruptions increasingly threaten settlement continuity, public infrastructure functionality, economic activity viability, and access to essential services, while concurrent institutional and fiscal constraints limit local adaptive capacity and long-term resilience building.

Governance Frameworks for Disaster Preparedness and Institutional Integration

International and national disaster management policy has progressively shifted the paradigm from a predominantly reactive, post-event response orientation toward proactive integration of disaster risk reduction with sustainable development planning and implementation. The United Nations Office for Disaster Risk Reduction (UNDRR, 2022) identifies core preparedness elements encompassing systematic risk assessment, multi-hazard early warning systems, community and institutional capacity development, forward-looking spatial planning, and resilient infrastructure investment. This

e-ISSN: 2830-5728

management-orientated framework is especially pertinent for outermost island jurisdictions where geographic isolation and transport constraints characteristically delay emergency response deployment and humanitarian assistance delivery, thereby amplifying the imperative for ex-ante institutional preparedness. Pelling's (2011) systematic analysis reveals that mitigation failures correlate more consistently with inadequate institutional capacity and ineffective policy coordination across levels of government than with insufficient hazard knowledge or technical understanding. This finding carries significant management implications: information gaps are not the primary constraint; rather, governance arrangements, inter-organisational coordination mechanisms, and institutional capacity determine implementation effectiveness. O'Brien et al. (2007) establish through comparative analysis that climate adaptation outcomes are substantially more favourable when integrated across multiple policy domains, including spatial planning, economic development, social protection systems, health infrastructure, transport connectivity, and disaster risk reduction, whereas siloed, sectoral governance produces overlapping programmes, inefficient resource deployment, and unclear institutional accountability.

METHODS

This study adopts a qualitative descriptive approach using a case study design combined with policy analysis to examine climate change impact mitigation and disaster preparedness on Miangas Island. Miangas was selected because it represents an outermost island exposed to climate-related hazards, limited accessibility, and strategic border security concerns. The analysis draws exclusively on secondary data collected through document analysis, including national legislation, government policy documents, official statistics, reports published by national and international organisations, and peer-reviewed literature on climate change, disaster risk reduction, coastal regions, and small islands. Key sources include Law No. 24 of 2007, Law No. 32 of 2009, Law No. 16 of 2016, Presidential Regulation No. 98 of 2021, together with publications issued by BNPB, BMKG, BIG, BPS, KKP, BRIN, IPCC, UNDRR, and WMO. Documents were selected purposively based on their relevance to the research objectives, source credibility, publication recency, and direct relationship with the environmental and institutional conditions of Miangas Island. Document analysis provides a systematic approach for examining policy frameworks and empirical evidence through verifiable documentary sources (Bowen, 2009).

The analysis proceeded in two stages. Content analysis was first employed to identify, categorise, and synthesise information into themes related to climate pressures, adaptive capacity, disaster preparedness, institutional arrangements, infrastructure, community participation, and border area governance (Schreier, 2012). SWOT analysis was subsequently applied to classify internal factors into strengths and weaknesses and external factors into opportunities and threats, thereby assessing the strategic position of Miangas Island and identifying priorities for strengthening climate change mitigation (Helms & Nixon, 2010). Source triangulation enhanced the credibility of the findings by comparing legislation, official statistics, government reports, international publications, and scholarly literature (Patton, 2015). The findings were finally interpreted through the Social-Ecological Systems Theory (Ostrom, 2009), the Disaster Risk Reduction Framework (UNDRR, 2022), and the *Asta Gatra*-based National Resilience framework (Lemhannas RI, 2022) to explain the relationship between climate pressures, institutional capacity, community preparedness, and resilience in Indonesia's border regions.

e-ISSN: 2830-5728

RESULT AND DISCUSSION

Result

Climate Exposure and Environmental Conditions on Miangas Island

Research findings indicate that Miangas faces mounting climate-related pressures affecting settlements, livelihoods, public infrastructure, and marine resources. Observational data record a local average surface temperature rise of approximately 0.6°C over the last two decades and a relative sea-level rise of about 4.3 mm per year. Additionally, the coastline has receded by roughly 2 to 3 metres in certain vulnerable coastal areas over the past five years. These changes heighten the risks of coastal flooding, saltwater intrusion, ecosystem degradation, and infrastructure damage.

The geographical characteristics of Miangas exacerbate this level of exposure. The island covers an area of approximately 3.15 km², with most of its territory situated less than 10 metres above mean sea level. Limited land area restricts options for relocating settlements and critical facilities to safer locations. Geographical isolation also amplifies the impact of disruptions, as the community's livelihood relies heavily on coastal and marine conditions as well as transportation access. Rising sea-surface temperatures in Indonesian waters further strain the ecosystems and fisheries that support household incomes and food security. Consequently, the vulnerability of Miangas stems from a combination of land constraints, low elevation, coastal changes, and a high dependence on marine resources.

Institutional and Operational Capacity

Disaster preparedness in Miangas has not kept pace with the island's level of exposure to climate impacts. The island lacks an integrated local early warning system capable of translating regional weather and oceanographic data into alerts that are both rapid and easily understood by the community. Evacuation facilities remain limited, and public buildings are not fully equipped with protective features, clean water, independent power sources, or emergency supplies to withstand extreme conditions. A shortage of trained personnel, combined with inadequate training in evacuation, emergency logistics, and risk communication, further constrains response capacity. While the mapalus tradition fosters community cooperation, effective preparedness still requires professional support, clear operational procedures, and regular drills.

Geographical conditions also affect the effectiveness of emergency operations, as both sea and air transport are highly weather-dependent. Transport disruptions can delay the distribution of food and medical aid, the deployment of personnel, and evacuation efforts during times of heightened emergency need. Limitations regarding warning systems, evacuation infrastructure, human resources, and transport access highlight a gap between the level of climate exposure and response capabilities. Table 1 summarises the relationship between climate exposure and response capabilities on Miangas Island. Rising temperatures, sea-level rise, and coastal abrasion heighten risks to coastal areas, while limitations in infrastructure, personnel, institutional coordination, and transport access hinder disaster preparedness. Consequently, strengthening the response requires integrating environmental monitoring, evacuation infrastructure, human resources, logistics, and institutional coordination.

e-ISSN: 2830-5728

Table 1. Climate Exposure, Preparedness, and Operational Conditions on Miangas Island

Aspect	Empirical condition	Implication
Climate exposure	Mean temperature increased by approximately 0.6°C; sea level rose by approximately 4.3 mm per year; coastal erosion reached 2 to 3 m in vulnerable areas.	Greater exposure to coastal flooding, shoreline retreat and ecosystem degradation.
Geographical characteristics	Small land area; elevation predominantly below 10 m above mean sea level; remote border location.	Geographic conditions intensify exposure to climate related hazards and limit relocation options.
Preparedness infrastructure	Integrated early warning systems remain unavailable; evacuation shelters and designated routes remain limited.	Limited infrastructure reduces the effectiveness of emergency warning and evacuation.
Institutional capacity	Trained disaster management personnel remain limited; cross sector coordination requires improvement.	Limited human resources and coordination constrain preparedness and emergency response.
Accessibility	Sea and air transport depend heavily on weather conditions.	Severe weather can delay logistics, humanitarian assistance and emergency evacuation.

Empirical evidence reveals a gap between increasing climate exposure and response capabilities on Miangas. Geographic conditions, infrastructure limitations, institutional capacity, and transport access influence the effectiveness of disaster preparedness. These findings serve as the basis for a SWOT analysis to identify strengths, weaknesses, opportunities, and threats, and to formulate strategies tailored to Miangas's characteristics as one of Indonesia's outermost islands.

SWOT Analysis of Climate Adaptation and Disaster Preparedness on Miangas Island

Miangas could enhance its adaptive capacity through collaboration with BRIN, universities, and international partners, as well as by leveraging climate finance schemes such as the Green Climate Fund, Thematic Special Allocation Funds (DAK Tematik), the Forest Carbon Partnership Facility, and REDD+, subject to their respective eligibility criteria. However, sea level rise, coastal erosion, ecosystem degradation, high logistics costs, shifting policy priorities, and low digital literacy continue to constrain the ability of communities and government institutions to respond effectively to climate risks. Table 2 outlines the internal and external factors that influence preparedness and adaptive capacity on Miangas.

e-ISSN: 2830-5728

Table 2. SWOT Analysis of Climate Adaptation and Disaster Preparedness on Miangas Island

STRENGTHS	WEAKNESSES
Social cohesion through the mapalus tradition	Early warning systems are not yet integrated
Strategic position as a border island	Limited mitigation and evacuation infrastructure
National policy support	Fragmented coordination among local government agencies
Potential site for climate observation and adaptation research	Limited disaster management human resources
	No dedicated local climate mitigation regulation

OPPORTUNITIES	THREATS
Climate adaptation funding schemes	Sea level rise, coastal erosion, and ecosystem degradation
Collaboration with BRIN, universities, and international partners	Geographical isolation and high logistics costs
Border area development programmes	Changing national policy priorities
Advances in climate monitoring and mitigation technologies	Limited digital literacy and technology adoption

The SWOT analysis indicates that social cohesion, strategic location, policy support, and collaborative networks serve as vital assets for strengthening Miangas's resilience. However, limitations regarding infrastructure, trained personnel, cross-sector coordination, and technology utilisation continue to hinder the effectiveness of preparedness efforts. Priority areas for improvement include integrating early warning systems, upgrading evacuation facilities, developing competencies, strengthening inter-agency coordination, and expanding access to technology and climate finance. The findings of this analysis serve as the basis for formulating the strategies presented in the following section.

Strategic Priorities

The interplay between internal and external factors yields four strategic directions. S-O strategies leverage social capital, support for border region development, and research partnerships to strengthen climate monitoring and local preparedness. W-O strategies utilise funding and technical support to enhance early warning systems, evacuation facilities, institutional capacity, and policy integration. S-T strategies optimise community cohesion and state presence to protect ecosystems and address coastal hazards, while W-T strategies mitigate institutional fragmentation and logistical vulnerabilities through contingency planning, emergency stockpiles, and communication technologies suited to remote island conditions.

This formulation results in six operational priorities: strengthening early warning systems, community preparedness, institutional coordination, resilient evacuation infrastructure, the availability of emergency logistics, and coastal ecosystem protection.

e-ISSN: 2830-5728

Integrated implementation can improve disaster response while simultaneously bolstering Miangas's long-term adaptive capacity.

Table 3. Formulation of Climate Adaptation and Disaster Preparedness Strategies for Miangas Island

Strategy	Formulation
S-O	Utilise the mapalus tradition, the island's strategic border location, and national policy support to strengthen collaboration with BRIN, universities, and development partners in establishing community-based climate monitoring and mitigation systems.
W-O	Use climate adaptation funding, technological support, and institutional partnerships to strengthen early warning systems, evacuation facilities, disaster management capacity, and local climate mitigation regulations
S-T	Capitalise on social cohesion, state presence, and the strategic role of Miangas Island to enhance community preparedness for sea level rise, coastal erosion, transport disruption, and pressures on coastal ecosystems
W-T	Reduce institutional fragmentation, logistical dependence, and technological limitations through contingency planning, cross-sector coordination, emergency logistics, and technologies suited to small island conditions

These four strategies underpin six operational priorities: strengthening early warning systems, enhancing community preparedness, fostering inter-agency coordination, developing resilient evacuation infrastructure, ensuring the availability of emergency logistics, and protecting coastal ecosystems. Their integrated implementation can bolster Miangas’s long-term disaster preparedness and adaptive capacity while ensuring that all efforts remain aligned with the island's geographical conditions and its strategic position as one of Indonesia's outermost islands.

Discussion

Climate Change Mitigation as a Social-Ecological System in Outermost Islands

Empirical results indicate that climate vulnerability in Miangas is shaped by the interaction between environmental exposure and adaptive capacity, rather than solely by physical hazards. Social-ecological systems theory posits that ecosystems, communities, and institutions collectively determine a region's resilience (Ostrom, 2009). Adger (2006) identifies exposure, sensitivity, and adaptive capacity as the primary dimensions of vulnerability, while Barnett and Adger (2003) demonstrate that resource constraints and limited economic opportunities exacerbate the vulnerability of small islands. Findings from Miangas support these explanations. Low elevation, land constraints, coastal erosion, and sea-level rise increase physical exposure, while the community's reliance on marine resources heightens sensitivity to ecological disruptions. Adaptive capacity is further constrained by inadequate infrastructure, a limited pool of skilled personnel,

e-ISSN: 2830-5728

suboptimal institutional coordination, and transportation access that is heavily dependent on weather conditions.

Social cohesion fostered by the mapalus tradition strengthens community participation and collective action; however, this social capital still requires support from early warning systems, evacuation facilities, professional capacity, and effective governance. Law No. 32 of 2009 and Law No. 24 of 2007 provide complementary frameworks for environmental protection and disaster risk reduction. Integrating these frameworks is crucial, as ecological degradation can disrupt livelihoods, the sustainability of settlements, and public services. Consequently, climate adaptation in Miangas not only bolsters environmental resilience but also safeguards the continuity of social and economic activities and public services in this strategically important border region.

Adaptive Governance and Institutional Integration

Institutional analysis indicates that the quality of governance determines the effectiveness of adaptation in Miangas. Fragmented responsibilities, siloed agency operations, and delayed risk information prevent infrastructure from offering optimal protection. Consequently, adaptive governance requires flexibility, coordination, institutional learning, and information exchange to respond to environmental uncertainties (Folke et al., 2005; Walker et al., 2004). Conditions in Miangas align with the findings of Pelling (2011) and O'Brien et al. (2007), who identify institutional fragmentation and weak policy integration as major barriers to climate action. While border development programmes, disaster management initiatives, and environmental policies have involved various agencies, their implementation has yet to establish an integrated operational mechanism.

The Sendai Framework for Disaster Risk Reduction 2015-2030 identifies coordination, risk information, institutional capacity, and community participation as essential elements of risk governance (UNDRR, 2015). Implementing this framework in Miangas requires a clear division of responsibilities among local government, the National and Regional Disaster Management Agencies (BNPB and BPBD), the National Search and Rescue Agency (BASARNAS), military border units, health services, and community organisations. Regional climate data must be translated into local warnings, evacuation procedures, and the designation of safe zones, while periodic drills can test operational readiness prior to emergencies. The mapalus tradition can strengthen community engagement in environmental monitoring, preparedness, and evacuation planning. Thus, adaptive governance in Miangas relies on inter-agency coordination, reliable communication, continuous learning, and community participation, rather than merely adding more regulations.

Climate Adaptation and National Resilience through *Asta Gatra*

The *Asta Gatra* framework places environmental pressures on Miangas within the broader structure of national resilience. Climate impacts first affect the *Tri Gatra* dimensions of geography, natural resources and demography before extending to the social dimensions of *Panca Gatra*. Coastal erosion, flooding and limited habitable land can disrupt settlements, infrastructure and public facilities, while marine ecosystem degradation can reduce fisheries productivity, household income and food availability. Prolonged environmental and economic pressure may also encourage the migration of working-age residents, thereby reduce local economic activity and affect community

e-ISSN: 2830-5728

continuity. The interaction between *Tri Gatra* and *Panca Gatra* shows how local climate pressures can extend from environmental disruption to wider economic, social, political, ideological, defence and security concerns, as illustrated in Figure 1.

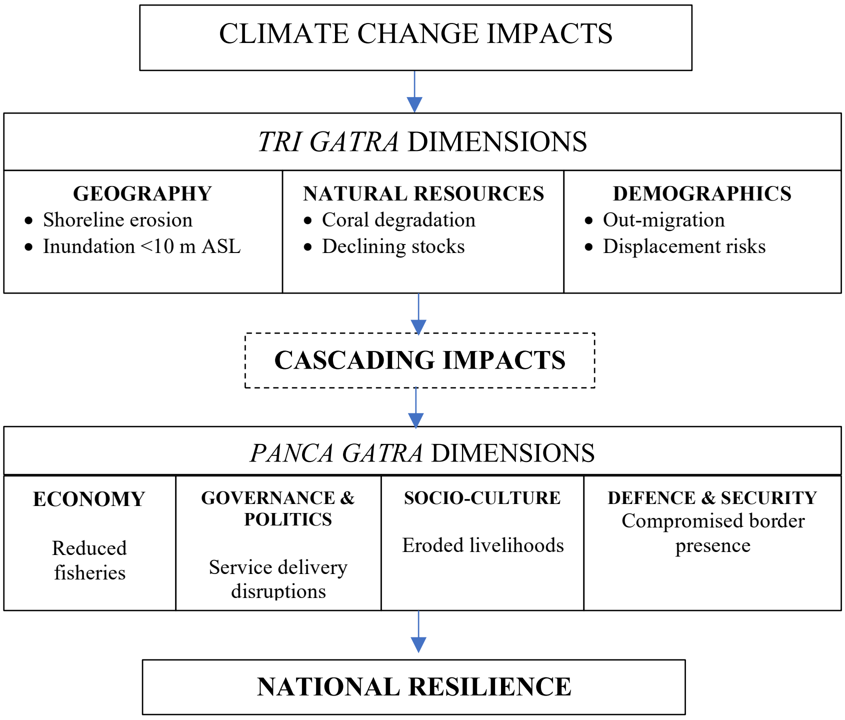

Figure 1. Cascading Climate Impacts across *Asta Gatra* Dimensions on Miangas Island
Source: Authors' synthesis based on the study findings.

Climate pressures begin to impact governance and security when they disrupt public services, the sustainability of settlements, and the exercise of state functions. Environmental changes do not automatically constitute security threats; however, ongoing degradation can heighten strategic vulnerabilities if it diminishes habitability, damages vital infrastructure, undermines livelihoods, or impedes governance in border regions. Consequently, the case of Miangas expands the concept of climate adaptation, moving beyond environmental sustainability and disaster risk reduction to encompass the protection of territorial integrity, sustained state presence, and the resilience of border communities. Law Number 16 of 2016 and Presidential Regulation Number 98 of 2021 provide the national framework for climate action, yet implementation requires adequate local capacity, reliable information, inter-agency coordination, and integration with regional development. Socio-ecological systems theory explains the interaction between the environment and society, adaptive governance describes institutional responses to change, and the *Asta Gatra* (Eight Aspects of National Life) framework situates both processes within the context of national resilience. Integrating these three perspectives reveals that ecological protection, community capacity, institutional coordination, and the continuity of government functions are essential elements for strengthening climate resilience on Indonesia's outermost islands.

e-ISSN: 2830-5728

CONCLUSION

Climate adaptation on Miangas Island still faces challenges in evolving into an integrated disaster preparedness system. The island's vulnerability stems from a combination of low elevation, coastal abrasion, sea-level rise, and reliance on marine resources, alongside inadequate institutional and operational capacities. Response capabilities remain constrained by issues regarding early warning systems, evacuation facilities, the availability of trained personnel, inter-agency coordination, and weather-dependent transport access. Nevertheless, the mapalus tradition, policy support for border regions, and Miangas's strategic location provide vital assets for strengthening adaptive capacity. The *Asta Gatra* perspective indicates that pressures on geography, natural resources, and demographics can extend to economic, social, governance, defence, and security aspects when climate change disrupts livelihoods, public services, and the sustainability of settlements.

The study's limitations primarily stem from its reliance on a single case study, a qualitative approach, and a predominance of document, policy, and SWOT analyses. Consequently, the findings are more robust for gaining an in-depth understanding of Miangas than for explaining causal relationships or representing all of Indonesia's outermost islands. Furthermore, the interrelationships between social-ecological systems theory, adaptive governance, and the *Asta Gatra* framework require broader empirical testing. Future research could enrich the study through inter-regional comparisons, mixed methods approach, longitudinal studies, and the use of primary data alongside geospatial, oceanographic, social, and economic indicators. Subsequent work should also examine each *Asta Gatra* dimension in more operational terms, evaluate policy implementation, and compare institutional performance across regions. Through such an approach, future research can strengthen the theoretical foundation while generating evidence that is relevant to climate adaptation policies and national resilience in border regions.

REFERENCE

Adger, W. N. (2006). Vulnerability. Global Environmental Change, 16(3), 268-281. DOI: 10.1016/j.gloenvcha.2006.02.006

Barnett, J., & Adger, W. N. (2003). Climate dangers and atoll countries. Climatic Change, 61(3), 321-337. DOI: 10.1023/B:CLIM.0000004559.08755.88

Badan Informasi Geospasial. (2022). Informasi geospasial wilayah Negara Kesatuan Republik Indonesia. BIG.

Badan Nasional Penanggulangan Bencana. (2024). Data Informasi Bencana Indonesia (DIBI). BNPB.

Badan Pusat Statistik. (2023). Statistik Indonesia 2023. BPS.

Badan Pusat Statistik Kabupaten Kepulauan Talaud. (2022). Kecamatan Miangas dalam angka 2022. BPS Kabupaten Kepulauan Talaud.

Berkes, F. (2007). Understanding uncertainty and reducing vulnerability: Lessons from resilience thinking. Natural Hazards, 41(2), 283-295. DOI: 10.1007/s11069-006-9036-7

Badan Riset dan Inovasi Nasional. (2021). Kajian strategis ketahanan iklim pulau-pulau terluar Indonesia. BRIN.

e-ISSN: 2830-5728

Copernicus Marine Service. (2024). Global Ocean Sea Surface Temperature trend map from Observations Reprocessing (Product ID: GLOBAL_OMI_TEMPSAL_sst_trend). Mercator Ocean International. DOI: 10.48670/moi-00243

Food and Agriculture Organization. (2024). The state of world fisheries and aquaculture 2024: Blue transformation in action. FAO.

Folke, C., Hahn, T., Olsson, P., & Norberg, J. (2005). Adaptive governance of social-ecological systems. Annual Review of Environment and Resources, 30, 441-473. DOI: 10.1146/annurev.energy.30.050504.144511

Intergovernmental Panel on Climate Change. (2023). Climate change 2023: Synthesis report. IPCC. DOI: 10.59327/IPCC/AR6-9789291691647

International Union for Conservation of Nature. (2020). Global standard for nature-based solutions. IUCN.

Kementerian Kelautan dan Perikanan. (2023). Kelautan dan perikanan dalam angka 2023. KKP.

Lembaga Ketahanan Nasional Republik Indonesia. (2022). Konsepsi ketahanan nasional Indonesia (Asta Gatra). Lemhannas RI.

O'Brien, K., Eriksen, S., Nygaard, L. P., & Schjolden, A. (2007). Why different interpretations of vulnerability matter in climate change discourses. Climate Policy, 7(1), 73-88. DOI: 10.1080/14693062.2007.9685639

Ostrom, E. (2009). A general framework for analyzing sustainability of social-ecological systems. Science, 325(5939), 419-422. DOI: 10.1126/science.1172133

Pelling, M. (2011). Adaptation to climate change: From resilience to transformation. Routledge.

Pemerintah Republik Indonesia. (2007). Undang-Undang Republik Indonesia Nomor 24 Tahun 2007 tentang Penanggulangan Bencana.

Pemerintah Republik Indonesia. (2009). Undang-Undang Republik Indonesia Nomor 32 Tahun 2009 tentang Perlindungan dan Pengelolaan Lingkungan Hidup.

Pemerintah Republik Indonesia. (2016). Undang-Undang Republik Indonesia Nomor 16 Tahun 2016 tentang Pengesahan Paris Agreement to the United Nations Framework Convention on Climate Change.

Pemerintah Republik Indonesia. (2021). Peraturan Presiden Republik Indonesia Nomor 98 Tahun 2021 tentang Penyelenggaraan Nilai Ekonomi Karbon untuk Pencapaian Target Kontribusi yang Ditetapkan Secara Nasional dan Pengendalian Emisi Gas Rumah Kaca dalam Pembangunan Nasional.

Trundle, A., Barth, B., & McEvoy, D. (2019). Leveraging endogenous climate resilience: Urban adaptation in Pacific Small Island Developing States. Environment and Urbanization, 31(1), 53-74. DOI: 10.1177/0956247818816654

United Nations Office for Disaster Risk Reduction. (2015). Sendai framework for disaster risk reduction 2015-2030. UNDRR.

United Nations Office for Disaster Risk Reduction. (2022). Global assessment report on disaster risk reduction 2022: Our world at risk. UNDRR.

World Meteorological Organization. (2025). State of the global climate 2024. WMO.