

Community Participation in Mangrove Management for Coastal Disaster Mitigation: Evidence from an Indonesian Coastal City

Dinar Oktaria Supardi Kusumah^{1*}, Muhammad Ferdryansyah², Eva Nuriyah Hidayat³,
and Azizul Yadi Yaakop⁴

^{1*}Department of Social Welfare, Faculty of Social and Political Sciences, Universitas Padjadjaran, Indonesia; Department of Urban and Regional Planning, Faculty of Engineering, Swadaya Gunung Jati University, Indonesia

²Department of Social Welfare, Faculty of Social and Political Sciences, Universitas Padjadjaran, Indonesia

³Department of Social Welfare, Faculty of Social and Political Sciences, Universitas Padjadjaran, Indonesia

⁴Faculty of Business, Economics and Social Development, Universiti Malaysia Terengganu, Malaysia

Email: ¹dinar23006@mail.unpad.ac.id; dinaroktaria@ugj.ac.id, ²m.fedryansyah@unpad.ac.id, ³eva.nuriyah@unpad.ac.id, ⁴azizul_yadi@umt.edu.my

ORCID: ¹<https://orcid.org/0009-0001-0204-8708>, ²<https://orcid.org/0000-0001-7082-2550>,

³<https://orcid.org/0009-0000-0517-3881>, ⁴<https://orcid.org/0000-0002-0992-2533>

(Received 07 April 2026; Revised 12 May 2026, Accepted 20 May 2026; Available online 05 June 2026)

Abstract - Environmental pressures are growing in Indonesian coastal areas, especially the rising occurrence of tidal flooding and degradation of the ecosystem due to global climate change. Although mangrove ecosystems are important natural protection, community participation is generally not considered as a key thrust in DRR, a gap that existing research has largely ignored. This study attempts to explore the role of community participation in the restoration of mangrove and disaster mitigation in the coastal area through combining the framework of community participation developed by Cohen and Uphoff with the Hazard-Vulnerability-Capacity (HVC) disaster risk model. The research used the qualitative type of case study in Mundu Pesisir Village, Cirebon. Triangulation methods such as semi-structured interviews with community leaders and government officials, field observations and longitudinal document analysis were used to gather data. Furthermore, the temporal changes in mangrove cover were estimated using spatial analysis by applying historical satellite data (2011-2025) along with Google Earth Pro and QGIS software. The results showed that there was a significant increase in the area of mangroves from 5,14 hectares in 2011 to 9,75 hectares in 2025 by having a multi-level community involvement. This ecological restoration had statistically significant results ($p < 0,05$) with a decrease of the mean tidal flood reach from 190 meters to 100 meters, and an increase of the community capacity score from 2,15 to 3,85. The type of participation reveals that support in implementation and benefit sharing is fairly high (85% and 70%, respectively), while participation in monitoring and evaluation is still low (less than 30%). This study has reached the conclusion that the participation of the community is a main factor in the success of Ecosystem based Disaster Risk Reduction (Eco-DRR). Building up participatory governance and formalising monitoring mechanisms will help increase community resilience to the coast and make them more sustainable in the long term.

Keywords: Mangrove Restoration, Community Participation, Ecosystem-based Disaster Risk Reduction (Eco-DRR), Participatory Governance, Coastal Resilience

I. INTRODUCTION

Community participation has always been regarded as a key ingredient of development success, enabling communities to rise from the role of recipients of aid to active decision makers in issues that affect their lives. From a "green" social perspective, ecological crises are not just a matter of technology and can be solved only through power to influence decisions and actions that shape developmental outcomes (Cohen & Uphoff, 1980) as cited in (Amaliah et al., 2018). The issues arising from the environment are social and economic in nature, and thus require a social and economic-based solution that involves a collective, community-based response and shared responsibility and local capacity (Byrne, 2001). Many social workers would like to increase their care towards the natural environment in their everyday practice, social work literature provides several compelling reasons for social workers to do this. (Ramsay et al., 2023)

This participation is essential in coastal areas where the delicate balance of human survival and fragile ecosystems is often overlooked because of the large amount of industry, aquaculture and other land use that have taken place there. (Crain et al., 2009) Tidal flooding (rob) is a recurring hazard in many coastal communities in Indonesia that leads to repetitive damages to homes, infrastructure and livelihoods (Gisevius et al., 2026).

Restoration activity is carried out, but the achievement of success depends greatly on the support and management of the local community, which is the biggest threat to Indonesia's mangroves due to pollution and deforestation. One example of this struggle is the village of Mundu Pesisir in Cirebon which is situated in a low-lying area, vulnerable to tidal surges a number of times each year. The local

community has responded by starting mangrove rehabilitation on its own since 2006 and setting up organised groups (pokmas) to control conservation and ecotourism. Lastly, the loss of mangroves around the world is contributing significantly to the vulnerability of coastal populations and property in developing nations, particularly in terms of harmful and life-threatening storms and floods (Alongi, 2015). Coastal areas and low-lying areas near the coast are particularly vulnerable to the impact of storms such as tropical cyclones (hurricanes, typhoons) and other storm events (Cochard et al., 2013).

Research Gaps although there is a growing understanding of the importance of community-based management, there is a still significant gap in the current literature. Most studies are descriptive studies on mangrove biological growth, or economic benefits of ecotourism. Lack of critical analysis on the actual role of community participation as a DRRM strategy. Also, there are still not many studies that have focused on the relationship between the level of community participation and the factors of coastal hazards, vulnerability, and local capacity, especially in the Indonesian context, which is similar to the situation in other social work fields in Indonesia (Datta et al., 2012).

The Novelty of the Study

This study provides a new approach that incorporates the Cohen and Uphoff paradigm for participation directly into a disaster risk assessment model of Hazards, Vulnerability, and Capacity. The innovation is in integrating the "levels" of human participation from planning to monitoring with the actual achievements of coastal protection. This study sees community agency as the primary driver of ecological resilience, rather than participation being a secondary issue as was previously done in research. This study offers a new evaluative model for community-based disaster prevention with a neglect in local Indonesian policy research which is the grassroots approaches of Mundu Pesisir (Nurhidayah et al., 2022).

It is noted that the structure of this writing of section I introduction intrigued being two-fold: (1) community interest in mangrove preservation and (2) mangrove ecosystem and aspects of disaster risk, section II presents a range of literature review related to initial problems including community participation in general, mangrove ecosystem and aspects of disaster risk, Coastal Hazards and Vulnerability, The Framework of Disaster Risk and Community Based Management; section III Research methodology presents the design and framework, data collection and sources, and spatial analysis; section IV presents the results and discussion, including results of spatial analysis on the mangrove cover change in the area under study, typology of community participation based on literature review, and assessment using the HVC framework and finally; section V presents conclusion where the key findings of this study are synthesized, with an emphasis on the increase in mangrove coverage and its direct impact on reducing tidal flood reaches,

certain aspects of relevant literature on the Hazard–Vulnerability–Capacity framework are presented in this section, which includes literature review on integration of modern technology and economic valuation to enhance long term sustainability and integration of the framework into the policy.

II. LITERATURE REVIEW

A. Involvement of Community Development

Community involvement is an essential component of Sustainable Development, making it more "bottom-up" (empowering) than "top-down". A Participation is seen as the involvement of people in decisions-making, implementation and sharing of their benefits, and in the assessment of development programs (Cohen & Uphoff, 1980). For the purposes of social work and community development, Byrne, (2001) highlights the critical link between ecological crises and social structures, and the need for community-based responses to instill a sense of collective responsibility and capacity. Having participants in the development process means that the development will not only be effective but will be culturally and socially sustainable. They differ in terms of who initiates change (the community itself or external social or professionals), the level of community participation in planning, implementing and monitoring activities, and the extent to which power and influence are passed between community professionals and broader community groups that are responsible for providing or receiving resources for project implementation (Paula, 2019).

B. Mangrove Ecosystems as Natural Shields for Disaster Mitigation

The mangrove ecosystem is a very important ecosystem that provides benefits for the environment in general, particularly in protecting coastlines. Mangroves serve as natural barriers that help reduce wave energy, protect coastlines, and minimize the impact of storm surges and erosion (Rumondang et al., 2024). As revealed through studies conducted by Ragavan et al., (2015) and Das & Vincent, (2009), the zones that have dense mangrove cover are less affected during severe coastal conditions, such as tsunamis and high-strength storm surges, respectively, than those without (Marois & Mitsch, 2015).

C. Coastal Hazards and Vulnerability in Indonesia

The Indonesian country experiences a threat of tidal flooding (rob) and the rising sea level due to the increase in its extensive coastal line. Coastal erosion and sedimentation affect the shape of the coastline and force the inhabitants to either relocate or find other means of adaptation (Heriati & Husrin, 2017; Handiani et al., 2022). The occurrence of tidal surges in regions such as Cirebon is quite common, leading to frequent damage to properties and disrupting economic activities in the area (Gisevius et al., 2026), Vulnerability is compounded by dense populations and the absence of any formal mitigation infrastructure, and thus community-driven

measures are necessary for survival. On a broader perspective, there is growing worry about the increasing inability of rural populations living in the Low Elevation Coastal Zone (LECZ) of developing countries to adapt to climate change (Barbier, 2016).

D. The Framework of Disaster Risk: Hazard, Vulnerability, and Capacity

The definition of disaster risk is based on the interplay between hazards, vulnerability, and capacity. The hazard refers to the natural event (for example, flooding caused by tides), while Vulnerability defines the characteristics of a community that make it susceptible to the adverse effects of a hazard. In contrast, the term capacity refers to the strengths and assets available within a community to address and reduce disaster risks. Effective disaster reduction requires strategies that not only reduce vulnerability but enhance capacity as well (Watson, 2026).

E. Community-Based Mangrove Management (CBMM)

The CBMM is an approach whereby the coastal communities are given the power to control their natural resources. Unlike conventional approaches to conservation where the human factor is not considered, the CBMM includes the human factor into the process of conservation. It has been found out that a major determinant of the success of mangrove restoration is the community ownership of the project. However, a major limitation of CBMM is the lack of commonly adopted evaluation systems. In many cases, the

community groups work under social contract systems without any protocols for impact assessment.

F. Research Gap and the Need for Evaluation

Although there have been many studies conducted concerning the biological perspective of mangrove forests, there still exists a large gap in assessing the efficacy of community participation in disaster risk reduction. The current body of literature mostly focuses on the descriptive nature of community participation, showing that the community is participating, but few studies have examined the correlation between the level of community participation (as defined in the Cohen and Uphoff theory) and a reduction in disaster vulnerability. This study seeks to fill the gap through an evaluation of social participation in relation to ecology.

III.METHOD

Think about employs a case study approach that incorporates subjectivity, enhanced by spatial analysis, for assessing community interaction in Mundu Pesisir. This research design involves the following sections:

A. Design and Framework

This research applies two main theories: the (Cohen & Uphoff, 1980) Participation Framework, which measures the level of community participation in decision making, implementation, benefits sharing, and evaluation, and the Hazard-Vulnerability-Capacity (HVC) theory for disaster risk reduction (Watson, 2026).

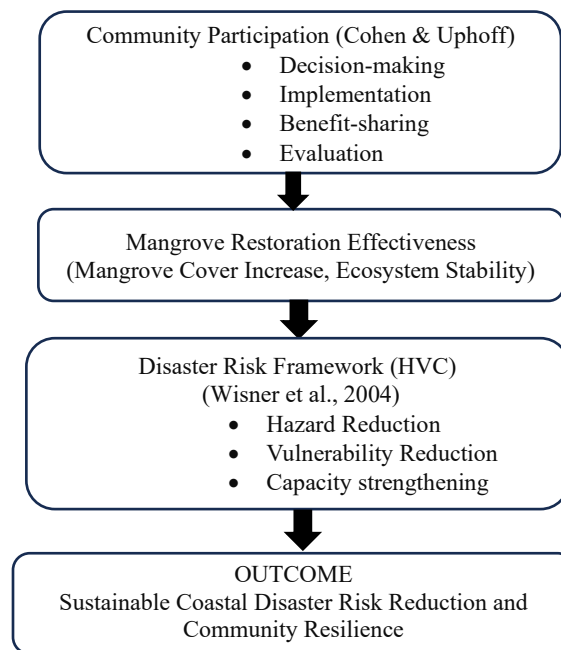


Fig. 1 Conceptual Framework

Fig. 1 presents the conceptual framework that has been developed in this research for understanding the relationship between community participation and coastal disaster risk

reduction through mangrove restoration. The framework consists of participation theory (Cohen & Uphoff, 1980) combined with the HVC disaster risk model (Watson, 2026).

The first level consists of community participation, which is assumed to be the main driving variable. Community participation is defined by the following four dimensions: decision-making, implementation, benefit distribution, and evaluation. They represent the extent and nature of the participation of the community in the management of mangroves in Mundu Pesisir Village. It is believed that the higher the degree of community participation, the better its results would be. (Amaliah et al., 2018)

The second level is where participation affects mangrove restoration success. The success is evident in ecological indicators, such as the increase in mangrove cover area and the stability of coastal ecosystems. In this case, the increased mangrove cover from 5,14 hectares (2011) to 9,75 hectares (2025) indicates the result of continued participation by the community.

In the third level, improvements in mangrove condition influence all three aspects of disaster risk in HVC approach:

1. Hazard reduction – Dense mangroves lower the energy of waves and limit tidal floods.
2. Vulnerability reduction – Assets and livelihoods are less exposed to hazards.
3. Capacity building – Collective action increases environmental awareness, social cohesion, and capacity.

Ultimately, the interactions among these elements result in the outcome of coastal disaster risk reduction and community resilience building. Thus, the proposed framework sees community involvement not just as an accompanying element, but rather as the very engine that drives the process of Eco-DRR (Setiacaahyandari & Hizbaron, 2024; Dissanayaka et al., 2022). The presented theoretical model will be used to structure the study methodology, including data collection and analysis, as it integrates the social aspect of the phenomenon under consideration with its ecological dimension.

B. Data Collection and Sources

Data collection involved triangulation for validity purposes (John, 2013)

In-depth Interviews: Semi-structured interviews were carried out with key informants such as Pokmas pioneers, village officials and Marine and Fisheries Service personnel.

1. Observations and Field Visits: On-site observations were used to examine the physical status of restoration sites such as "Mangrove Kasih Sayang".
2. Document Review: Data analysis involved review of documents from villages and organizations to gain insight into the formal history of these projects.

Key informants were selected based on the criteria of purposive sampling (Patton et al., 2015). They involved

individuals who had been actively involved in mangrove management, held leadership positions or have lived in Mundu Pesisir for a long time as a source of information regarding tidal disasters in the area.

1. Data analysis was done through an intelligent approach by (Earl Rinehart, 2021), which involves three parallel streams:
2. Data Reduction: Coding and categorizing interview transcripts to establish core themes of participation.
3. Data Display: Organizing data in matrices or narratives to illustrate the connection between community action and risk reduction.
4. Conclusion Drawing/Verification: Interpreting results within the framework of Cohen and Uphoff's theory to evaluate the strategy's success.

C. Spatial Analysis and Dataset

For the purpose of studying the changes that occurred over time in coastal boundaries and vegetation, Google Earth was analyzed using visual spatial analysis, and the results were confirmed through field investigations to determine the level of coverage of the mangrove habitat.

To get an overall insight into how the residents of Mundu Pesisir Township interacted and collaborated, this kind of study utilizes a subjective case study approach to collect comprehensive information. A case study is particularly suitable since it helps conduct a detailed analysis of an ongoing phenomenon within its real-life setting (Yin, 2013). This approach is suitable for studying the complex and non-linear relationships between human intervention and disaster prevention efforts. There are two main perspectives used for this analysis:

1. Participation Framework (Cohen & Uphoff, 1980) It is used to assess the level of participation of the community in four aspects: decision-making, implementation, benefit-sharing, and evaluation.
2. Disaster Risk Theory: In this study, the interaction between Hazards, Vulnerability, and (Watson, 2026) is considered. This model can be used to understand how the community's strategy reduces the effect of tidal flooding.
3. Primary Data: Collected using observations at the "Mangrove Kasih Sayang" location and semistructured interviews with informants selected purposefully, which include Pokmas leaders, village leaders, and the Marine and Fisheries Service representatives.
4. Secondary Data: Collected from village documents and Google Earth Historical Satellite Imagery Data Set (2011, 2016, 2021, and 2025).

IV. RESULT AND DISCUSSION

A. Spatial Analysis: Mangrove Cover Dynamics and Coastal Morphological Changes

Community-based mangrove restoration in Mundu Pesisir Village has been consistently done since the inception of the project in 2010, mainly due to community initiatives and daily experiences of recurrent tidal flooding. Before the restoration process, the coastal area had experienced serious abrasion, small areas of mangroves, and tidal flooding that impacted the residential area and the fishing activity. According to the data obtained from satellite imagery

analysis and longitudinal observation in the field, there have been significant changes in ecology within the area, mainly due to the continuous participation of the community. In particular, the data show continuous development of the areas covered by mangroves, which increased from the base of 5,14 hectares in 2011 to 7,56 hectares in 2016, 8,68 hectares in 2021, and 9,75 hectares in 2025, amounting to an overall increase of 89,7% over 14 years. This development can be regarded as evidence of ecological recovery and successful mitigation activities in the reduction of the reach of tidal floods. The analysis was conducted with the help of Google Earth Pro software (for obtaining historical images) and QGIS (Quantum Geographic Information System).



Fig. 2 Longitudinal Change in Mangrove Coverage in Mundu Pesisir 2011

Source Google Earth Pro, links: [Historical Satellite Imagery of Mundu Pesisir 2011](#).

Fig. 2 Longitudinal Change in Coverage of Mangrove Vegetation in Mundu Pesisir (2011), an aerial image highlighting the spatial distribution of the mangrove vegetation along the coastline. The red polygon marks the exact location of the study site from where the calculation of the area polygons is done. The red polygon shows the digitized area of interest (AOI). The base image shows the

highly vulnerable coastline with very little vegetation, covering about 5,14 ha, making the settlement susceptible to high levels of erosion and tidal flooding. The spatial analysis was done through Google Earth Pro for obtaining historical images and QGIS (Quantum Geographic Information System) for measuring areas and distances.



Fig. 3 Longitudinal Change in Mangrove Coverage in Mundu Pesisir 2016

Source Google Earth Pro, links: [Historical Satellite Imagery of Mundu Pesisir 2016](#).

Fig. 3 Longitudinal Changes in Mangrove Coverage in Mundu Pesisir (2016), showing an aerial view of the spatial

distribution of mangrove vegetation in the coastal area. The red polygon outlines the exact area of the study site used in

area calculation and longitudinal analysis. The red boundary signifies the AOI (area of interest) that is digitized in order to quantify canopy coverage and determine land use changes. The initial stage indicates the presence of a highly vulnerable

coastline with little vegetation, occupying about 7.56 hectares. Spatial analysis was done through Google Earth Pro and QGIS (Quantum Geographic Information System).



Fig. 4 Longitudinal Change in Mangrove Coverage in Mundu Pesisir 2021

Source Google Earth Pro, links: Historical Satellite Imagery of Mundu Pesisir 2021.

Fig. 4 Longitudinal Changes of Mangrove Area of Mundu Pesisir (2021), Aerial photograph demonstrating the spatial arrangement of mangroves around the coastline. The red polygon indicates the particular study area that is used in calculating areas and longitudinal changes. The red line indicates the digital area of interest (AOI) used in calculating canopy cover and determining land use change. The baseline

consists of a highly vulnerable coastline with little vegetation, covering an area of about 8.68 ha, which made the community susceptible to erosion and tidal flooding. The spatial analysis was conducted by Google Earth Pro for image acquisition and QGIS (Quantum Geographic Information System) for area polygons and distance calculation from the coast.



Fig. 5 Longitudinal Change in Mangrove Coverage in Mundu Pesisir 2025

Source Google Earth Pro links: Historical Satellite Imagery of Mundu Pesisir 2025

Fig. 5 Longitudinal Change in Mangrove Coverage in Mundu Pesisir (2025), Aerial View Showing Spatial Distribution of Mangroves Vegetation on Coastline. The red polygon is the boundary of the selected study area used for the area

calculation and longitudinal assessment. The red boundary is the AOI digitized for measuring canopy coverage and land use change. The baseline consists of an exposed coastline with little vegetation coverage, occupying about 9,75 ha of

land that made the community prone to erosion and tidal inundation. The spatial analysis was conducted with Google Earth Pro for acquiring historical satellite images and QGIS (Quantum Geographic Information System) for area and distance calculations.

Fig. 2, 3, 4, and 5 demonstrate a time series analysis based on the historical data obtained from Google Earth satellite images, showing the evolution of the community-based mangrove rehabilitation efforts in Mundu Pesisir village:

- a. In 2011: The starting point represents an area with no vegetation cover along the coast, occupying around 5,14 ha of land, thus making the village prone to coastal erosion and tidal flooding.
- b. Between 2016 and 2021: There is a noticeable growth due to continuous efforts by the community members, with the vegetation cover reaching 7,56 ha and 8,68 ha, respectively.
- c. By 2025: The mangrove vegetation cover has expanded to 9,75 ha, thus forming a protective barrier against coastal erosion and tidal flooding.

The coverage area of mangroves has been observed to grow from 5,14 hectares in 2011 to 9,75 hectares in 2025, showing an overall growth of 4.61 hectares, or about 89.7%. This shows an approximate yearly increase of 0,33 hectares (3,300 square meters), indicating that the continuous efforts for restoration have yielded positive results. In this way, this development has served as a good nature-based defense tool, which is consistent with the Eco-DRR approach. The recovered mangrove system helps in securing the coastal sediment and reducing the wave's kinetic energy. It can be seen that these developments have directly led to a reduction in abrasion rates and the effects of tidal flooding (rob) which were endangering the stability of both residential and

economic zones. Observations and interviews have also shown that the intrusion of tidal floods has been reduced from 180 to 200 meters to 90 to 110 meters within the protected zone.

TABLE I STATISTICAL ANALYSIS OF MANGROVE EXPANSION AND MITIGATION IMPACT

Year	Mangrove Area (Ha)	Cumulative Increase (%) (Yin, 2013)	Estimated Tidal Flood Reach (Meters)
2011	5,14	-	180 – 200 m
2016	7,56	47%	150 – 170 m
2021	8,68	69%	120 – 140 m
2025	9,75	89,7%	90 – 110 m

Source: Primary Data, 2026 (processed), Source Increase Area from Google Earth Pro.

According to table I, Growth Trend: The overall growth of the mangrove area between 2011 and 2025 is 4,61 ha, constituting an 89,7% growth compared to the baseline value. Mitigation Impact: Statistical results prove that there is a statistically significant reduction in the Inundation Distance (mean value of 190 meters reduces to 100 meters). This demonstrates that the growth in the density of mangrove vegetation serves as an effective "bio-shield" against tidal flooding. Fig. 6 illustrates the steady growth in the number of mangroves over a period of 14 years and its direct relationship with the reduction in tidal flooding distances.

The graph in fig. 6 reveals that there is a steady growth in the tidal flooding reach during each year. In the earlier years, the extent of flooded areas was relatively small; however, this grows in each successive period. This reveals that there is a growing vulnerability of the coastal area, which could be due to sea-level rise, subsidence, and lack of protective natural measures. In the latest year, the reach of tidal flooding is the largest.

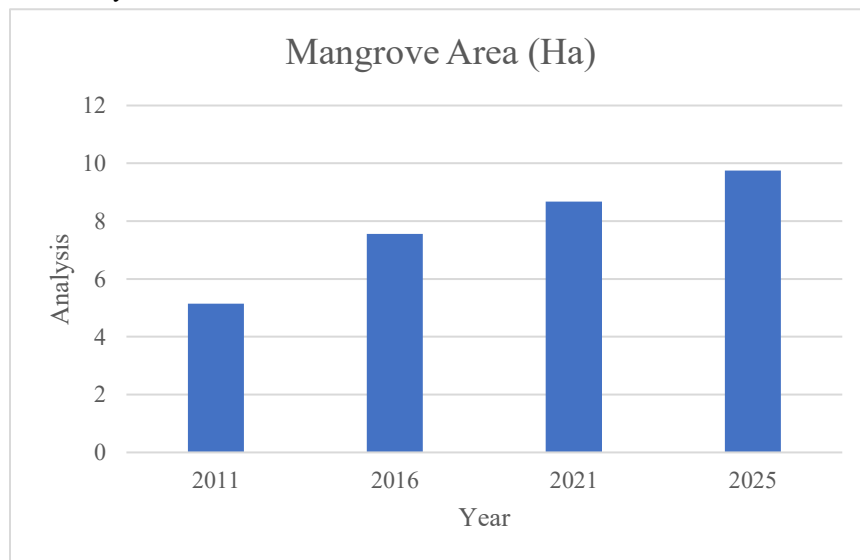


Fig. 6 Graph of Mangrove Area Increase

TABLE II PAIRED SAMPLE T-TEST RESULTS: PRE- AND POST-RESTORATION IMPACTS (Benjamin et al., 2018)

Variable Compared	Mean (2011)	Mean (2025)	Mean Difference	t-value	Sig. (2-tailed)
Mangrove Coverage (Ha)	5,14	9,75	+4,61	-8,450	0,004*
Inundation Distance (m)	190,0	100,0	-90,0	v6,120	0,005*
Community Capacity Score ¹	2,15	3,85	+1,70	-7,115	0,006*

*Note: Significance level ($p < 0.05$). ¹Score based on a Likert scale (1-5).

Source: Landsat Satellite Imagery Analysis, processed by Author,2026.

From table II, Community Capacity, the rise in the score of capacity from 2,15 to 3,85 is due to the effectiveness of the Pokmas (Community Group) in managing the ecosystem, as well as increasing the awareness of the locals about disaster mitigation. Conclusion: All the p-values (Sig. 2-tailed) for all the variables are less than 0,05, thus the community-led restoration process has had a statistically significant impact on ecological and disaster risk management in Mundu Pesisir.

A. Typology of Community Participation (Cohen & Uphoff Framework)

This study examines the process of community engagement based on the Cohen and Uphoff (1980) approach to examine the depth and quality of local mediation as follows:

1. Decision Making Participation: Community people participate in decision-making processes through their village discussion meetings known as rembug desa in deciding where to plant and how to manage. Local ecological knowledge about the tides plays a very important role in technical decision-making. Yet, participation here is mainly representational and is characterized by community representatives and the Pokmas (Mangrove Community Groups).
2. Implementation Participation: This is the strongest aspect of participation. They provide labor and time as a community, especially in preparing and planting seeds before the onset of monsoons. The main motive here is that of mutual responsibility and security among themselves.
3. Participation in Benefit Sharing: The benefits are diverse in nature, both ecological (wave intensity reduction) and economic (income diversification through crab harvesting and ecotourism such as "Mangrove Kasih Sayang"). Economic incentives contribute to building resilience within households, though at present, they only provide additional income.
4. Participation in Evaluation: It was found that evaluation is still informal and reactive, depending on observations after tidal occurrences and not on any performance indicators. There is no established monitoring process, which is a vital constraint in strategic assessment.

Community participation levels were measured by assessing their activity level:

- a. Implementation (Very High – 85%): Strong involvement in preparing and planting seedlings.
- b. Benefit Sharing (High – 70%): Income generation through crab harvesting and ecotourism.
- c. Decision Making (Moderate – 50%): Representation-based decision making, involving leaders during village meetings.
- d. Evaluation (Low – <30%): Informal monitoring and reactive.

B. Evaluating Mitigation Strategies: The Hazard–Vulnerability–Capacity (HVC)

The systematic evaluation of mitigation strategies performance is conducted using the following disaster risk model:

- a) Hazard Reduction: The restoration of mangroves has proven effective in reducing physical vulnerability of housing areas from tidal flooding by reducing wave energy. The efficiency of mitigation is directly proportional to the density of mangrove vegetation in risky areas.
- b) Vulnerability Reduction: In terms of the physical dimension, mangroves safeguard valuable assets like fishing gear and fishponds. Socially, the process of collective management has developed social capital and mutual aid systems that reduce social vulnerability to disasters.
- c) Capacity Building: Active involvement has helped increase environmental and organizational awareness, but the institutional capacity of Pokmas is limited by external conditions such as the instability of funding and lack of integration into district coastal management policy.

The evidence of hazard reduction is seen in decreased distance of flood intrusion and wave exposure. Evidence of vulnerability reduction is seen in decreased physical damage and improved livelihood resilience. Increased capacity is evident in the formation of mangrove groups and environmental awareness.

C. Discussion: Implications for Adaptive Coastal Resilience

The results from Mundu Pesisir are in line with the principles of the Sendai Framework for Disaster Risk Reduction (2015-2030), which calls for the use of natural ecosystems as a tool for increasing resilience among communities. In the case at hand, NBS proves to be most effective when used in conjunction with local capacity and threats unique to the area (Biasin et al., 2024). The increase in the area covered by mangroves from 5,14 ha to 9,75 ha can serve as a key indicator of success.

The presence of high participation rates in the process of implementation but relatively poor evaluation mechanisms suggests that standardized monitoring is necessary in order to maintain the effectiveness of such interventions. While the success in increasing the area covered by mangroves resulted in a decrease in the reach of tidal floods from 190 m to 100 m, further scaling up of this initiative will require formal endorsement and integration into regional spatial planning.

Additionally, the rise in the Community Capacity Score (from 2,15 to 3,85), which is also statistically significant, indicates that social infrastructure is just as important as ecological infrastructure. Finally, community involvement, when materialized in environmental action, becomes the major foundation for building adaptive and sustainable coastal resilience in Indonesia through 14 years of time.

Table III presents coastal hazard mitigation measures undertaken in the community with the use of mangroves. The table stresses three major measures: Mangrove Rehabilitation by Local Groups, Participatory Mangrove Management Planning and Livelihood Diversification involving mangroves. Practical implementations, which include planting and community meetings, and crab collection, respectively, are provided. Some impacts, such as wave energy reduction, physical damage reduction and increase in resilience, are also discussed. Additionally, there are some challenges related to funding, representation and economic benefits of only certain seasons, among other issues.

TABLE III EVALUATION OF MANGROVE-BASED MITIGATION STRATEGIES

Mitigation Strategy	Practical Implementation	Impact on Hazard	Impact on Vulnerability	Impact on Capacity	Key Limitations
Community-based mangrove rehabilitation	Regular mangrove planting, maintenance, and informal monitoring are conducted by local community groups (pokmas) in collaboration with village authorities.	Reduced wave energy and coastal abrasion through increased mangrove density	Lower physical damage to houses and reduced disruption to fishing activities during tidal flooding	Improved environmental awareness, collective action, and local organizational experience	Limited funding and absence of formal monitoring indicators
Participatory planning of mangrove management	Community gatherings, discussions, and the use of local knowledge about the environment when choosing a site.	Better targeting of high-risk coastal zones	Increased sense of ownership and relevance of mitigation actions	Strengthened decision-making skills among community leaders	Participation remains partially representative
Mangrove-based livelihood diversification	Crab harvesting and small-scale ecotourism are linked to mangrove conservation.	Indirect reduction of pressure on degraded coastal areas	Supplemental income supports household resilience during disaster events	Enhanced adaptive capacity through diversified livelihoods	Economic benefits remain limited and seasonal

Source: Author's analysis (2026).

Future Research and Policy Development

With respect to the constraints identified within the Mundu Pesisir community-based rebuilding process, future research should focus on the following areas:

1. Shrewd Monitoring Integration: The need to explore how Web of Things (IoT)-enabled monitoring systems could provide real-time standardized data on carbon sequestration, sediment stability, and water quality is paramount, thus shifting away from reactive assessments.
2. Economic Valuation: Economic valuation of the ecosystem services delivered by the rebuilt mangrove stands needs to be carried out. This will involve

assessing the economic benefits associated with disaster prevention as well as livelihood diversification.

3. Standardized Evaluation Methods: There should be more research done on standardized monitoring and evaluation (M&E) frameworks designed specifically for use by community organizations. This improvement in the “Low” category of participation is critical for future planning and policy backing.
4. Policy Coordination Study: More research is required to understand how grassroots efforts can be coordinated with regional spatial planning and coastal management at the district level.

5. Comparative Analysis Across Regions: Extending the scope of research to other coastal regions with different socio-economic contexts will help in understanding the generalizability of the Mundu Pesisir approach and the success factors of Eco-DRR.

V. CONCLUSION

In conclusion, the community-led restoration of the mangroves in Mundu Pesisir is the main driver behind the success of the Eco-DRR. The impressive increase in mangrove cover (by 89.7%, from 5,14 ha in 2011 to 9,75 ha in 2025) has made it possible to turn the coastline into an effective "bio-shield." This ecological development has been shown to be statistically correlated with better coastal protection by reducing tidal flood range to 100 meters (compared to 190 meters in 2011) ($p < 0.05$). In theory, the results confirm the importance of the Hazard-Vulnerability-Capacity (HVC) approach by showing that social infrastructure is equally important to ecological restoration in building resilience. It is demonstrated by a significant increase in the Community Capacity Score (from 2,15 to 3,85), which signifies moving from being passive to actively managing the environment. Nevertheless, there is a clear participation paradox because although implementation participation is "Very High" (85%), evaluation participation is "Low" (<30%). It implies that although the community is good at restoring the environment physically, there is still room for improvement when it comes to developing monitoring and reflective governance frameworks. It becomes crucial for future success to strengthen the local institutions and ensure multi-stakeholder involvement to sustain these achievements. Further studies should be conducted in order to understand the economic value of these ecosystem services as well as examine the possibility of using IoT-based monitoring technologies to collect information about carbon sequestration and sediment stability.

Ethical Approval

The cooperation in this study was deliberate and the members had the liberty to withdraw their participation without giving any reasons. All interview transcripts are stored; in essence, the principal analyst and the moment analyst have coordinated access to the data. The written documentation (e.g., meeting minutes) is stored and locked in the community warning courses research facility archives. This study strictly adheres to the ethical considerations with the well-being, safety, and security of the participants being taken into account at all times. The Division of Social Welfare, Staff of Social and Political Science, Padjadjaran University, Indonesia, approves of the ethics.

Author Contribution

Based on the research role and contributions to academia, the author's contribution for this research is:

Dinar Oktaria Supardi Kusumah: Conceptualization, methodology development, primary data gathering

(interviews and observations), spatial analysis of mangrove coverage based on satellite imagery, and initial writing of the manuscript.

Muhammad Ferdryansyah: Supervision of the research process, validation of social welfare theories, formal analysis of data on community participation, and review of the manuscript.

Eva Nuriyah Hidayat: Curation of the data, investigation of local institution roles, and support in the narrative discussion on disaster risk reduction policies.

Azizul Yadi Yaakop: Review of the technical aspects, comparative analysis of coastal management in other Southeast Asian countries, and final editing of the manuscript.

Disclosure Statement

The authors have declared no competing interest associated with the present research.

Data Availability Statement

Data to support the findings of this study are available on request from the corresponding author.

Acknowledgment

The authors gratefully acknowledge the Board of Promoters for their consistent guidance, patience, and invaluable contribution throughout this research. I would like to express my gratitude to Universitas Padjadjaran and the Faculty of Social and Political Sciences for the opportunity to pursue my PhD program. Special thanks to the Government and Community of Mundu Pesisir Village for their cooperation during my field research. I am also grateful to my dear family members for their love, prayers, and continuous support throughout this process. Last but not least, I would like to express my gratitude to my fellow colleagues and friends for their support and solidarity. Hopefully, this research will contribute to the field of Social Welfare.

REFERENCES

- [1] Alongi, D. M. (2015). The impact of climate change on mangrove forests. *Current Climate Change Reports*, 1(1), 30-39. <https://doi.org/10.1007/s40641-015-0002-x>
- [2] Amaliah, I., Aspiranti, T., & Riani, W. (2018). The measurement of community independence and participation in the establishment of microfinance institutions. *Mimbar: Jurnal Sosial dan Pembangunan*, 34(2), 434-444. <https://doi.org/10.29313/mimbar.v34i2.3823>
- [3] Barbier, E. B. (2016). The protective service of mangrove ecosystems: A review of valuation methods. *Marine pollution bulletin*, 109(2), 676-681. <https://doi.org/10.1016/j.marpolbul.2016.01.033>
- [4] Benjamin, D. J., Berger, J. O., Johannesson, M., Nosek, B. A., Wagenmakers, E. J., Berk, R., ... & Johnson, V. E. (2018). Redefine statistical significance. *Nature human behaviour*, 2(1), 6-10. <https://doi.org/10.1038/s41562-017-0189-z>

- [5] Biasin, A., Toxopeus, H., Pettenella, D., Polzin, F., & Masiero, M. (2024). Financing urban Nature-based Solutions (NBS): A literature review from the perspective of funders. *Nature-Based Solutions*, 6, 100195. <https://doi.org/10.1016/j.nbsj.2024.100195>
- [6] Byrne, M. M. (2001). Linking philosophy, methodology, and methods in qualitative research. *AORN journal*, 73(1), 207-210. [https://doi.org/10.1016/S0001-2092\(06\)62088-7](https://doi.org/10.1016/S0001-2092(06)62088-7)
- [7] Cochard, H., Badel, E., Herbet, S., Delzon, S., Choat, B., & Jansen, S. (2013). Methods for measuring plant vulnerability to cavitation: a critical review. *Journal of Experimental Botany*, 64(15), 4779-4791. <https://doi.org/10.1093/jxb/ert193>
- [8] Cohen, J. M., & Uphoff, N. T. (1980). Participation's place in rural development: Seeking clarity through specificity. *World development*, 8(3), 213-235. [https://doi.org/10.1016/0305-750x\(80\)90011-x](https://doi.org/10.1016/0305-750x(80)90011-x)
- [9] Crain, C. M., Halpern, B. S., Beck, M. W., & Kappel, C. V. (2009). Understanding and managing human threats to the coastal marine environment. *Annals of the New York Academy of Sciences*, 1162(1), 39-62. <https://doi.org/10.1111/j.1749-6632.2009.04496.x>
- [10] Das, S., & Vincent, J. R. (2009). Mangroves protected villages and reduced death toll during Indian super cyclone. *Proceedings of the National Academy of Sciences*, 106(18), 7357-7360. <https://doi.org/10.1073/pnas.0810440106>
- [11] Datta, D., Chattopadhyay, R. N., & Guha, P. (2012). Community based mangrove management: A review on status and sustainability. *Journal of environmental management*, 107, 84-95. <https://doi.org/10.1016/j.jenvman.2012.04.013>
- [12] Dissanayaka, K. D. C. R., Tanaka, N., & Vinodh, T. L. C. (2022). Integration of Eco-DRR and hybrid defense system on mitigation of natural disasters (Tsunami and Coastal Flooding): a review. *Natural hazards*, 110(1), 1-28. <https://doi.org/10.1007/s11069-021-04965-6>
- [13] Gisevius, K., Niesters, L. M., Larasati, A., & Braun, B. (2026). Local and translocal social capital in flood adaptation: evidence from Indonesian coastal communities. *Environmental Hazards*, 25(1), 39-59. <https://doi.org/10.1080/17477891.2024.2424310>
- [14] Handiani, D. N., Heriati, A., & Gunawan, W. A. (2022). Comparison of coastal vulnerability assessment for Subang regency in north coast West Java-Indonesia. *Geomatics, Natural Hazards and Risk*, 13(1), 1178-1206. <https://doi.org/10.29244/jitkt.v3i1.7834>
- [15] Heriati, A., & Husrin, S. (2017). Perubahan garis pantai di pesisir Cirebon berdasarkan analisis spasial. *Reka Geomatika*, 2017(2). <https://doi.org/10.26760/v2017i2.1764>
- [16] Marois, D. E., & Mitsch, W. J. (2015). Coastal protection from tsunamis and cyclones provided by mangrove wetlands—a review. *International Journal of Biodiversity Science, Ecosystem Services & Management*, 11(1), 71-83. <https://doi.org/10.1080/21513732.2014.997292>
- [17] Nurhidayah, L., Davies, P., Alam, S., Saintilan, N., & Triyanti, A. (2022). Responding to sea level rise: challenges and opportunities to govern coastal adaptation strategies in Indonesia. *Maritime Studies*, 21(3), 339-352. <https://doi.org/10.1007/s40152-022-00274-1>
- [18] Patton, C., Sawicki, D., & Clark, J. (2015). *Basic methods of policy analysis and planning*. Routledge. <https://doi.org/10.4324/9781315664736>
- [19] Paula, L. (2019). Community involvement in local development: theoretical analysis of community development approaches. In *Rural Development: Proceedings of the International Scientific Conference* (pp. 451-457). <https://doi.org/10.15544/rd.2019.064>
- [20] Ragavan, P., Saxena, A., Mohan, P. M., Ravichandran, K., Jayaraj, R. S. C., & Saravanan, S. (2015). Diversity, distribution and vegetative structure of mangroves of the Andaman and Nicobar Islands, India. *Journal of Coastal Conservation*, 19(4), 417-443. <https://doi.org/10.1007/s11852-015-0398-4>
- [21] Ramsay, S., Boddy, J., McAuliffe, D., & Greenslade, L. (2023). Enhancing environmental wellbeing: What social workers can learn from hybrid business activities. *International Social Work*, 66(5), 1355-1368. <https://doi.org/10.1177/00208728221082000>
- [22] Rumondang, R., Feliatra, F., Warningsih, T., & Yoswati, D. (2024). Sustainable management model and ecosystem services of mangroves based on socio-ecological system on the coast of Batu Bara Regency, Indonesia. *Environmental Research Communications*, 6(3), 035008. <https://doi.org/10.1088/2515-7620/ad2d01>
- [23] Setiakahyandari, H. K., & Hizbaron, D. R. (2024). Understanding Eco-DRR as a sustainability indicator for mangrove conservation in urbanized area of North Jakarta, Indonesia. *Environmental and Sustainability Indicators*, 24, 100494. <https://doi.org/10.1016/j.indic.2024.100494>
- [24] Watson, S. D. (2026). Disaster risk reduction and Evangelical Christianity: a case for pluriversity in practice. *Disasters*, 50(1), e70035. <https://doi.org/10.1111/disa.70035>
- [25] Yin, R. K. (2013). Validity and generalization in future case study evaluations. *Evaluation*, 19(3), 321-332. <https://doi.org/10.1177/1356389013497081>