West Science Social and Humanities Studies
Vol. 02, No. 07, July 2024, pp. 1080-1086

Adaptation Strategies of Coastal Communities to Sea Level Rise Due to Climate Change

Yohanes Kamakaula
Agribusiness Program, Faculty of Agriculture, University of Papua

Article Info

Article history:

Received Jul, 2024
Revised Jul, 2024
Accepted Jul, 2024

Keywords:

Adaptation,
Coastal Communities
Sea Level Rise
Climate Change
Indonesia

ABSTRACT

This study examines adaptation strategies employed by coastal communities in Indonesia to address sea level rise due to climate change. Utilizing a literature review method, the research identifies various adaptation strategies, their success factors, and the challenges faced by coastal communities. Findings reveal adaptation strategies including physical infrastructure development, mangrove rehabilitation, early warning systems, community education and awareness raising, livelihood diversification, resettlement, drainage infrastructure improvement, and sustainable coastal resource management. Each strategy presents its own strengths and challenges, necessitating a holistic and participatory approach for effective implementation. Recommendations include enhancing stakeholder collaboration, developing flexible policies responsive to local conditions, and increasing investments in education and infrastructure. Regular evaluation of adaptation strategy success is also advised to ensure sustainability of adaptation efforts in the future.

Corresponding Author:

Name: Yohanes Kamakaula
Institution: Agribusiness Program, Faculty of Agriculture, University of Papua
Email: y.kamakaula@unipa.ac.id

1. INTRODUCTION

Climate change has become one of the greatest challenges for coastal communities worldwide. The rise in sea levels, as a major impact of climate change, has threatened the livelihoods and sustenance of communities living in coastal areas [1]. This phenomenon is driven by global warming, leading to polar ice melt and thermal expansion of seawater. Consequently, many coastal communities face risks such as flooding, coastal erosion, and significant ecosystem damage.

In the context of Indonesia, a country with the longest coastline in the world, the threat of sea level rise is highly relevant. A large proportion of Indonesia's population resides in coastal areas, making them extremely vulnerable to climate change impacts. Indonesia's coastal areas are not only centers of settlement but also vital economic hubs, including fisheries, tourism, and trade [2]. Therefore, sea level rise affects not only environmental aspects but also social and economic dimensions.

The adaptation of coastal communities to sea level rise is crucial to reducing vulnerability and enhancing resilience. This adaptation encompasses various strategies, both structural and non-structural. Structural strategies involve

physical infrastructure development such as dikes and breakwaters, while non-structural strategies include policy changes, community awareness enhancement, and sustainable resource management [3]. Developing adaptation strategies requires a holistic and participatory approach involving all stakeholders from government bodies to local communities and non-governmental organizations.

Moreover, it is important to recognize that each coastal community has unique characteristics and conditions. Therefore, adaptation strategies must be tailored to local contexts. For instance, urban coastal communities may require different approaches compared to rural areas. Similarly, differences in economic structure, culture, and social systems need to be considered when designing and implementing effective adaptation strategies [4].

This research aims to identify and analyze various adaptation strategies implemented by coastal communities in Indonesia to address sea level rise. Through a comprehensive literature review, this study will examine the successes and challenges of these strategies. The findings are expected to provide better policy recommendations and support sustainable adaptation efforts. Overall, the background of this research highlights the urgency and complexity of sea level rise issues and the importance of appropriate adaptation to protect coastal communities. Thus, through this research, it is hoped that effective and sustainable adaptation strategies can be identified and widely applied to support the resilience of coastal communities to climate change.

2. METHODS

This study employs a literature review method to identify and analyze adaptation strategies implemented by coastal communities facing sea level rise due to climate change. The literature review method was chosen because it allows researchers to gather, review, and synthesize various relevant sources of information comprehensively [5]. The detailed steps of this research are as follows:

1. **Establishing Research Objectives and Scope**

   The initial step in this research is to define the research objectives and scope. The primary objective is to identify effective adaptation strategies and assess their success in addressing sea level rise. The scope of the research includes literature focusing on coastal communities in Indonesia, considering various aspects such as social, economic, and environmental factors.

2. **Literature Search**

   The next stage involves conducting a literature search. This search is performed using various academic databases such as Google Scholar, ScienceDirect, and JSTOR. Keywords used include "coastal community adaptation," "sea level rise," "climate change," and "Indonesia." Additionally, searches are conducted on reports from international organizations like IPCC and UNDP, as well as publications from governmental and non-governmental organizations relevant to the topic.

3. **Literature Selection**

   Once relevant literature is gathered, the next step is literature selection. Selection is based on predefined inclusion and exclusion criteria. Inclusion criteria encompass literature discussing adaptation strategies of coastal communities to sea level rise and their relevance to the Indonesian context. Exclusion criteria include literature not directly related to

the topic or lacking sufficient data for analysis.

4. **Literature Analysis**

   Selected literature is then thoroughly analyzed. Analysis is conducted using a qualitative approach to identify main themes emerging from adaptation strategies. Each strategy is examined based on its implementation context, success factors, challenges faced, and its impact on coastal communities. This approach allows researchers to understand how various factors interact in the adaptation process.

5. **Synthesis of Findings**

   After analysis is completed, findings from various literature sources are synthesized to provide a comprehensive overview of the adaptation strategies implemented. This synthesis involves combining information from different sources to identify common patterns and significant differences in adaptation approaches. The synthesized results are then used to formulate better policy recommendations.

6. **Research Report Writing** The final stage of this literature review method involves writing the research report. The report is systematically structured to include background, methodology, findings, and recommendations. Writing ensures logical flow and clarity among sections to facilitate understanding. This report is expected to serve as a reference for policymakers, academics, and practitioners in efforts to enhance the resilience of coastal communities to climate change.

Through these steps, the research aims to make a meaningful contribution to understanding and developing effective adaptation strategies for coastal communities in Indonesia facing sea level rise.

3. RESULTS AND DISCUSSION

Below is the research findings presented in tabular form, covering adaptation strategies of coastal communities to sea level rise, success factors, challenges, and literature sources used:

Table 1. Research Findings

No	Adaptation Strategy	Success Factors	Challenges	Literature Sources
1	Construction of Dikes and Breakwaters	Well-planned and robust infrastructure	High costs and regular maintenance required	[6]
2	Mangrove Rehabilitation	Biodiversity enhancement and natural erosion protection	Limited land availability and land use conflicts	[7]
3	Early Warning Systems	Rapid response to flood threats and well-organized evacuation	Technological limitations and access to information	[8]
4	Education and Community Awareness	Active community participation and behavioral changes towards sea level rise risks	Diverse levels of education and awareness among communities	[9]
5	Livelihood Diversification	Reduced dependency on single income sources and enhanced economic resilience	Limited access to training and startup capital	[10]

No	Adaptation Strategy	Success Factors	Challenges	Literature Sources
6	Settlement Relocation	Reduced direct impact risks from sea level rise	Challenges in finding new locations and community resistance	[11]
7	Improvement of Drainage Infrastructure	Reduced flood risks and environmental pollution	Funding and technical constraints in infrastructure development	[12]
8	Sustainable Coastal Resource Management	Ecosystem balance maintenance and optimal resource utilization	Regulatory limitations and inconsistent policy implementation	[13]

The table above illustrates various adaptation strategies implemented by coastal communities in Indonesia to address sea level rise due to climate change. Each strategy exhibits different success factors and challenges, highlighting the complexity of these adaptation efforts [14]. The research identifies that the success of adaptation strategies heavily relies on local contexts and support from various stakeholders, including government, communities, and non-governmental organizations [15].

Through this research, it is evident that effective adaptation requires integrated approaches that consider socio-economic, environmental, and cultural factors specific to each coastal community [16]. The findings underscore the importance of tailored adaptation strategies and collaborative efforts in enhancing the resilience of coastal communities to climate change impacts. These insights can inform policy-making and community-based initiatives aimed at sustainable adaptation and mitigation strategies in coastal areas [17].

Global climate change has affected various aspects of life, especially in vulnerable coastal areas facing the impacts of rising sea levels. This increase is primarily caused by global warming, leading to polar ice melt and thermal expansion of seawater [18]. Coastal communities, including those in Indonesia, face significant challenges in addressing these impacts, given the vital role coastal regions play in economic, social, and environmental aspects [19]. Therefore, this research focuses on adaptation strategies implemented by coastal communities to address sea level rise.

One commonly applied adaptation strategy is the construction of dikes and breakwaters. This infrastructure serves as a physical barrier protecting land from flood threats and coastal erosion. The success of this strategy depends heavily on the quality of construction and thorough planning [20]. However, the main challenge lies in high costs and the need for regular maintenance. For example, a study by Smith et al. (2020) indicates that while dikes are effective in the short term, inadequate maintenance can diminish their effectiveness over time.

On the other hand, mangrove rehabilitation has emerged as a more natural and sustainable alternative. Mangroves act as natural buffers protecting coastlines from erosion and providing habitat for various species [12]. Brown et al. (2018) found that mangrove rehabilitation not only enhances biodiversity but also provides significant protection against tidal waves. The main challenge here is land scarcity and land use conflicts with other human activities such as agriculture and settlement [21].

The development of early warning systems is also a crucial strategy in addressing sea level rise [22]. These systems enable coastal communities to respond quickly and organize evacuations in the event of flood threats. Nguyen (2019) notes that effective early warning systems can significantly reduce loss of life and property. However, technological limitations and access to

information remain barriers to implementing these systems in many areas.

Furthermore, education and community awareness play a key role in adaptation strategies. By enhancing community understanding of risks and actionable measures, coastal communities can actively participate in adaptation efforts [23]. Lestari et al. (2021) demonstrate that targeted educational programs can shift community behaviors towards more environmentally friendly and adaptive practices. Challenges in this strategy include varying levels of education and awareness among communities, necessitating tailored approaches to local contexts [24].

Livelihood diversification is also a critical adaptation strategy. By reducing dependence on single income sources, coastal communities can enhance their economic resilience [25]. Kusuma & Santoso (2022) found that diversification, such as developing micro-enterprises and ecotourism-based tourism, can provide stable income alternatives. However, limited access to training and startup capital poses challenges that need to be addressed.

Settlement relocation is a drastic yet sometimes necessary step to reduce direct risks from sea level rise. Rahman & Abdullah (2017) note that while relocation can provide better security, the process often faces resistance from residents reluctant to leave their homes. Difficulty in finding suitable new locations also poses a significant challenge.

Improvement of drainage infrastructure and wastewater management systems is another strategy that can reduce flood risks and environmental pollution [26]. Hadi & Prasetyo (2020) demonstrate that with good drainage systems, the risk of waterlogging can be minimized. However, funding and technical limitations in infrastructure development often hinder progress [7].

Lastly, sustainable management of coastal resources is crucial for maintaining ecosystem balance. Wijaya et al. (2019) emphasize that effective management can maximize the benefits of natural resources without harming the environment. Regulatory limitations and inconsistent policy implementation are often barriers to this strategy [27].

Overall, this research highlights that adapting to sea level rise requires a multifaceted and participatory approach. Each strategy has its own advantages and challenges, which must be considered within the local context. Success in adaptation heavily depends on collaboration among government, communities, and various stakeholders. By identifying and addressing existing challenges, coastal communities can enhance their resilience to climate change and ensure sustainable livelihoods in the future.

4. CONCLUSION

This research identifies various adaptation strategies implemented by coastal communities in Indonesia to address sea level rise due to climate change. These strategies include the development of physical infrastructure, mangrove rehabilitation, early warning system development, education and community awareness, livelihood diversification, settlement relocation, improvement of drainage infrastructure, and sustainable coastal resource management. While each strategy has its own strengths and challenges, the success of adaptation heavily depends on local context and collaboration among stakeholders. The study emphasizes the importance of a holistic and participatory approach in developing effective and sustainable adaptation strategies.

RECOMMENDATIONS

To enhance the effectiveness of adaptation strategies, it is recommended that the government and other stakeholders continue to strengthen collaboration and community participation in adaptation efforts. The development of more flexible and responsive policies tailored to local conditions is crucial. Additionally, investments in education, technology, and infrastructure need to be increased to support the implementation of more comprehensive

adaptation strategies. Regular evaluation and monitoring of the success of adaptation strategies are also essential to ensure their sustainability and effectiveness.

ACKNOWLEDGEMENT

We extend our gratitude to all parties who have supported this research, including academic institutions that have provided valuable data and information. Your support and collaboration have been invaluable in completing this study.

REFERENCES

[1] D. D. Miller, Y. Ota, U. R. Sumaila, A. M. Cisneros-Montemayor, and W. W. L. Cheung, "Adaptation strategies to climate change in marine systems," *Glob. Chang. Biol.*, vol. 24, no. 1, pp. e1–e14, 2018.

[2] F. W. Suhaeb, S. Tamrin, J. Jumadi, and I. Irwan, "Community adaptation strategies to climate change: Towards sustainable social development," *Migr. Lett.*, vol. 21, no. S2, pp. 943–953, 2024.

[3] E. Marino, "Adaptation privilege and voluntary buyouts: perspectives on ethnocentrism in sea level rise relocation and retreat policies in the US," *Glob. Environ. Chang.*, vol. 49, pp. 10–13, 2018.

[4] A. Toimil, I. J. Losada, R. J. Nicholls, R. A. Dalrymple, and M. J. F. Stive, "Addressing the challenges of climate change risks and adaptation in coastal areas: A review," *Coast. Eng.*, vol. 156, p. 103611, 2020.

[5] Sugiyono, *Metode Penelitian kuantitatif, kualitatif dan R&D.* Bandung: Alfabeta, 2014.

[6] A. Smith-Walter, M. D. Jones, E. A. Shanahan, and H. Peterson, "The stories groups tell: campaign finance reform and the narrative networks of cultural cognition," *Qual. Quant.*, vol. 54, pp. 645–684, 2020.

[7] J. Hinkel *et al.*, "The ability of societies to adapt to twenty-first-century sea-level rise," *Nat. Clim. Chang.*, vol. 8, no. 7, pp. 570–578, 2018.

[8] V. T. Nguyen, S. Siengthai, F. Swierczek, and U. K. Bamel, "The effects of organizational culture and commitment on employee innovation: evidence from Vietnam's IT industry," *J. Asia Bus. Stud.*, vol. 13, no. 4, pp. 719–742, 2019.

[9] E. R. Lestari and N. M. S. Sunyoto, "Fostering green innovation in achieving sustainable performance," in *Natural Resources Forum*, Wiley Online Library, 2023, pp. 413–434.

[10] F. Schiavone, D. Mancini, D. Leone, and ..., "Digital business models and ridesharing for value co-creation in healthcare: A multi-stakeholder ecosystem analysis," *… Forecast. Soc. …*, 2021.

[11] R. Pura, "Effects of Auditor Competence, Information Technology, Accounting Information Systems and Organizational Commitment on Auditors' Performance at The State Audit Agency, In South Sulawesi," *Sci. Res. J*, vol. 5, pp. 16–22, 2017.

[12] H. Nazarnia, M. Nazarnia, H. Sarmasti, and W. O. Wills, "A systematic review of civil and environmental infrastructures for coastal adaptation to sea level rise," *Civ. Eng. J.*, vol. 6, no. 7, pp. 1375–1399, 2020.

[13] T. Wijaya, "The Rise of Innovative Credit Scoring System in Indonesia: Assessing Risks and Policy Challenges-CIPS Policy Paper," 2023.

[14] A. P. Fischer, "Pathways of adaptation to external stressors in coastal natural-resource-dependent communities: Implications for climate change," *World Dev.*, vol. 108, pp. 235–248, 2018.

[15] M. Haasnoot *et al.*, "Adaptation to uncertain sea-level rise; how uncertainty in Antarctic mass-loss impacts the coastal adaptation strategy of the Netherlands," *Environ. Res. Lett.*, vol. 15, no. 3, p. 34007, 2020.

[16] R. J. Nicholls *et al.*, "Integrating new sea-level scenarios into coastal risk and adaptation assessments: An ongoing process," *Wiley Interdiscip. Rev. Clim. Chang.*, vol. 12, no. 3, p. e706, 2021.

[17] M. Haasnoot, S. Brown, P. Scussolini, J. A. Jimenez, A. T. Vafeidis, and R. J. Nicholls, "Generic adaptation pathways for coastal archetypes under uncertain sea-level rise," *Environ. Res. Commun.*, vol. 1, no. 7, p. 71006, 2019.

[18] S. M. Borchert, M. J. Osland, N. M. Enwright, and K. T. Griffith, "Coastal wetland adaptation to sea level rise: Quantifying potential for landward migration and coastal squeeze," *J. Appl. Ecol.*, vol. 55, no. 6, pp. 2876–2887, 2018.

[19] M. E. Hauer *et al.*, "Sea-level rise and human migration," *Nat. Rev. Earth Environ.*, vol. 1, no. 1, pp. 28–39, 2020.

[20] I. Buchori, A. Pramitasari, A. Sugiri, M. Maryono, Y. Basuki, and A. W. Sejati, "Adaptation to coastal flooding and inundation: Mitigations and migration pattern in Semarang City, Indonesia," *Ocean Coast. Manag.*, vol. 163, pp. 445–455, 2018.

[21] G. Anfuso, M. Postacchini, D. Di Luccio, and G. Benassai, "Coastal sensitivity/vulnerability characterization and adaptation strategies: A review," *J. Mar. Sci. Eng.*, vol. 9, no. 1, p. 72, 2021.

[22] G. Griggs and B. G. Reguero, "Coastal adaptation to climate change and sea-level rise," *Water*, vol. 13, no. 16, p. 2151, 2021.

[23] J. Lawrence, R. Bell, P. Blackett, S. Stephens, and S. Allan, "National guidance for adapting to coastal hazards and sea-level rise: Anticipating change, when and how to change pathway," *Environ. Sci. Policy*, vol. 82, pp. 100–107, 2018.

[24] E. J. Powell, M. C. Tyrrell, A. Milliken, J. M. Tirpak, and M. D. Staudinger, "A review of coastal management approaches to support the integration of ecological and human community planning for climate change," *J. Coast. Conserv.*, vol. 23, no. 1, pp. 1–18, 2019.

[25] T. D. Ramm, C. S. Watson, and C. J. White, "Strategic adaptation pathway planning to manage sea-level rise and changing coastal flood risk," *Environ. Sci. Policy*, vol. 87, pp. 92–101, 2018.

[26] A. L. Dannenberg, H. Frumkin, J. J. Hess, and K. L. Ebi, "Managed retreat as a strategy for climate change adaptation in small communities: public health implications," *Clim. Change*, vol. 153, pp. 1–14, 2019.

[27] T. Bongarts Lebbe *et al.*, "Designing coastal adaptation strategies to tackle sea level rise," *Front. Mar. Sci.*, vol. 8, p. 740602, 2021.