International Journal of Sustainable Development and Planning
Vol. 20, No. 7, July, 2025, pp. 3085-3093
Journal homepage: http://iieta.org/journals/ijsdp

Sendai Framework for Managing Marine Abrasion Disasters on Bengkalis Island

Sylvina Rusadi*, Syaprianto, Eko Handrian, Dita Fisdian Adni

Department of Government Science, Universitas Islam Riau, Riau 28284, Indonesia

Corresponding Author Email: sylvinarusadi@soc.uir.ac.id

https://doi.org/10.18280/ijsdp.200733

Received: 21 April 2025
Revised: 30 June 2025
Accepted: 12 July 2025
Available online: 31 July 2025

Keywords:
Sendai Framework, disaster risk, abrasion disaster, data access, cross-sector coordination

ABSTRACT

The marine abrasion disaster on Bengkalis Island, Riau, is a serious problem that threatens the survival of coastal communities and existing ecosystems, with significant impacts on the economy, society and environment, so a comprehensive approach is needed to overcome it through the implementation of the Sendai Framework as a global framework for disaster risk reduction. This research aims to identify and analyze the level of abrasion vulnerability on Bengkalis Island and evaluate the local government's prevention and mitigation efforts in addressing abrasion problems through the implementation of the Sendai Framework. This research was conducted over three months, utilizing qualitative methods with a case study approach. Data were collected through observation, documentation, and in-depth interviews with key informants, as well as data analysis using NVivo 12 software to present findings clearly and in a structured manner. The main findings of this research indicate that the Sendai Framework offers a comprehensive approach to managing marine abrasion disasters on Bengkalis Island, but faces criticism regarding overlapping authority and a lack of coordination between stakeholders. Additionally, more valid statistical data is needed to ensure effective decision-making. To improve implementation, it is recommended that an effective coordination forum and transparent information distribution be established, and a more integrated and sustainable mitigation approach be developed. Suppose challenges in coordination and data access still need to be addressed. In that case, implementing the Sendai Framework to mitigate the marine abrasion disaster on Bengkalis Island has the potential to fail, resulting in greater impacts on an already vulnerable community and environment.

1. INTRODUCTION

Marine abrasion or erosion disasters occur when waves and ocean currents gradually erode land along the coastline, causing land loss and damage to coastal ecosystems [1-3]. The adverse impacts of sea abrasion are very significant for coastal communities, especially in economic and social aspects [4, 5]. Marine abrasion can eliminate productive land used for agriculture or settlement, thereby threatening residents' livelihoods [6]. In addition, abrasion often exacerbates damage to infrastructure such as roads, buildings and other public facilities, increasing repair and restoration costs [7, 8]. Coastal ecosystems such as mangrove forests, coral reefs and beaches, which play an important role in maintaining environmental balance, are also damaged by abrasion, resulting in loss of habitat for various marine and terrestrial species [9, 10].

In the long term, marine abrasion or erosion can potentially increase the risk of other disasters, such as flooding and seawater intrusion, which can worsen environmental conditions and public health [11, 12]. Land loss due to abrasion also triggers social conflict, especially when residents must be relocated from affected areas [13]. Effective marine abrasion mitigation approaches such as building embankments, planting coastal vegetation, and rehabilitating natural ecosystems are very important to reduce this adverse impact [14-16]. However, other findings also show that coordinated government policies with a community-based approach are urgently needed to overcome marine abrasion's negative impacts sustainably [17, 18].

Management of marine abrasion disasters generally involves structural and non-structural approaches. Structural approaches include the construction of physical infrastructure such as breakwaters, sea walls, and retaining walls, which aim to reduce the force of waves reaching the coast and protect the land from further erosion [19-21]. On the other hand, non-structural approaches involve the rehabilitation of natural ecosystems such as mangrove forests and coral reefs, which function as natural barriers to abrasion [22, 23]. Apart from that, public education, appropriate spatial planning, and environmental protection policies by the government also play a role in reducing the impact of abrasion [24, 25]. Other cases also show that effective abrasion mitigation requires collaboration between government, communities and other stakeholders to ensure a sustainable and integrated approach [26].

The marine abrasion disaster in Indonesia is a serious problem considering that this country consists of thousands of islands spread from Sabang to Merauke, with a very long coastline. The natural beauty of Indonesia's coast, which is rich in ecosystems such as mangrove forests and coral reefs, is

increasingly threatened by the abrasion phenomenon, which erodes land every day due to waves and sea currents [27, 28]. This abrasion damages the natural environment and threatens the survival of coastal communities that depend on the land for agriculture, settlement and livelihoods. Areas such as the North Coast of Java, Sumatra, and Sulawesi are often the areas most affected, with significant land loss from year to year [26, 28-30].

Bengkalis Island in Bengkalis Regency, Riau Province, is one of Indonesia's coastal areas that has experienced significant erosion, with a major economic and social impact on the local community. This abrasion eliminates the livelihoods of the community, the majority of whom are shrimp farming farmers and fishermen, and also forces residents to lose their homes because they have to be relocated. The urgency of dealing with abrasion on Bengkalis Island is very high, considering its strategic position directly opposite Malaysia in the Malacca Strait, which is important economically and from the perspective of regional resilience and national security. The levels of damage on the Bengkalis coast, ranging from low to high, with abrasion rates of more than 5 meters per year in some areas, demand serious attention from local and central governments [26, 31].

One of the steps to effectively handle abrasion disasters can be done through the implementation of the Sendai Framework, which is a joint responsibility of countries under the auspices of the United Nations to reduce global disaster risks [32-34]. The Sendai Framework offers guidance with four main priorities, namely improving disaster risk assessment, institutional synergy and resilience of risk governance, strengthening risk management investments, and increasing readiness for effective response [35]. The implementation of the Sendai Framework in Indonesia has been accommodated through Presidential Regulation Number 87 concerning the 2020-2044 Disaster Management Master Plan, which confirms the government's commitment to handling disasters, both those that have occurred and those that have the potential to occur in the future [36]. In the context of marine abrasion, the implementation of this framework is very relevant because it allows governments and stakeholders to not only respond to ongoing disasters but also prevent and mitigate risks in vulnerable coastal areas, such as Bengkalis Island.

Several studies in Southeast Asia have demonstrated that the implementation of the Sendai Framework has had a positive impact on disaster risk reduction in coastal areas by controlling coastal erosion. For example, in Vietnam, the Sendai Framework's four-priority approach has been successfully implemented through collaboration between the government, local communities, and international institutions in coastal ecosystem rehabilitation and adaptive infrastructure development [37]. In Thailand, community-based disaster education programs and geospatial technology-based risk mapping have also strengthened community preparedness for coastal erosion and flooding [38]. Compared to Indonesia, the implementation of the Sendai Framework in these countries tends to be more integrated with regional development policies and is accompanied by consistent budget support.

The research gap in mitigating marine abrasion disasters on Bengkalis Island lies in the lack of a comprehensive study that integrates the Sendai Framework as a disaster risk reduction framework with the specific conditions of abrasion in the region. Even though the Sendai Framework has been applied globally, its application in the context of marine abrasion, especially in coastal areas such as Bengkalis Island, has still been minimally discussed in previous research. Most studies focus more on structural mitigation, such as building embankments or breakwaters, without paying attention to approaches based on risk governance and increasing community preparedness. The novelty of this research lies in combining the four priorities of the Sendai Framework—risk assessment, institutional synergy, strengthening risk investment, and response readiness—into a strategy for handling marine abrasion on Bengkalis Island. This research offers a response model that is not only reactive to the impacts of abrasion but also proactive in increasing the capacity of local communities and institutions to face the threat of abrasion in the future.

This research aims to identify and analyze the level of vulnerability to abrasion on Bengkalis Island and evaluate the prevention and mitigation efforts carried out by the local government through the implementation of the Sendai Framework. This research aims to integrate approaches based on risk assessment, institutional synergy, strengthening risk management investments, and response readiness in strategies for handling marine abrasion disasters, with the hope of increasing the effectiveness of mitigation and strengthening the capacity of local communities and institutions in facing the threat of abrasion in the future. Thus, this research can significantly contribute to increasing understanding of abrasion vulnerability on Bengkalis Island and strengthening mitigation efforts through the application of the Sendai Framework to create a society that is more resilient to disaster risks.

2. METHOD

This research was conducted for three months, from July to October 2023, with the object being the abrasion phenomenon on Bengkalis Island, located in Bengkalis Regency, Riau Province. This island has a strategic position because it directly faces Malaysia, bordered by the Strait of Malacca in the north. The abrasion on this island has a major impact on the local community's environment, economy, and social aspects. This research examines the application of the Sendai Framework in dealing with marine abrasion disasters on Bengkalis Island, especially in efforts to prevent and mitigate the impacts of further abrasion.

The research method chosen is qualitative with a case study approach, which is relevant for describing in depth the abrasion phenomenon that occurs on Bengkalis Island. The selection of qualitative methods in this study is based on the need to explore the phenomenon of sea abrasion in depth on Bengkalis Island and understand the contextual application of the Sendai Framework in disaster mitigation and prevention efforts. This method allows researchers to capture the subjective perspectives of informants and social dynamics that cannot be measured quantitatively. The first step in this research was a literature review of various national and international journal articles that discussed similar topics related to disaster management and implementing the Sendai Framework. This literature study helps researchers understand the theoretical context and policies implemented in various regions so that it can be used as a reference in designing research that focuses on the case of Bengkalis Island.

Data was collected through several techniques, including primary and secondary data collection. Primary data was collected through pre-research observations, allowing

researchers to understand field conditions and conduct initial interviews with people directly affected by abrasion. Meanwhile, secondary data is a form of documentation from various official sources such as government reports, scientific publications, and policy documents related to abrasion and its management. From the initial observations and interviews, the researcher drafted a proposal describing the problem and research objectives in detail.

Key informants in this research include the Head of the Prevention and Preparedness Division of the Bengkalis Regency BPBD, the Head of the Rehabilitation and Reconstruction Division of the Bengkalis Regency BPBD, the Head of Simpang Ayam Village, as well as the people of Simpang Ayam Village who were affected by abrasion. This also includes affected citizens, NGOs, and private sector representatives. Interviews were conducted in-depth to gather information regarding abrasion management and implementing the Sendai Framework in the region. Data obtained from interviews was then coded and analyzed using NVivo 12 software, which facilitates thematic analysis and data visualization so that research results can be presented clearly and structured.

To ensure the credibility and validity of the data, triangulation of sources and methods was employed, involving the combination of field observations, in-depth interviews with key informants, and analysis of documentation from various official sources. The data collection process was carried out in stages, starting from initial observations to understand empirical conditions, followed by semi-structured interviews focused on the informants' experiences and understanding of abrasion and policy implementation. In addition, the potential for bias was minimized by verifying the findings through comparisons between data sources and considering the diversity of perspectives from various actors involved in the abrasion issue on Bengkalis Island.

All data obtained was then transcribed in detail to ensure the information obtained from the informants was accurate. Once the transcription process was complete, the data was imported into NVivo 12 software for further analysis. In NVivo, data is coded using a case classification approach, where each informant and data category is organized as a separate unit of analysis. This coding process allows the researcher to identify the main themes that emerge from the data and relate these findings to predetermined categories. Using case classification, researchers can conduct a comparative analysis between various responses from different informants so that thematic analysis can be carried out in-depth and research results are presented in a clearer, more structured and evidence-based manner.

3. RESULTS

Knowing the level of abrasion vulnerability on Bengkalis Island is important for determining priorities for handling the most affected areas. This also helps in planning appropriate mitigation measures so that the impact of abrasion can be minimized effectively. The levels of abrasion vulnerability on Bengkalis Island can be seen in Table 1.

The levels of abrasion vulnerability on Bengkalis Island can be seen in Table 1, which shows the length of the beach being eroded and the rate of abrasion per year at various locations. Based on this data, four locations experience high levels of abrasion, with a total length of beach abrasion reaching 22,000 meters and an abrasion rate reaching 7 meters per year. Furthermore, there are four locations with moderate levels of abrasion, which have a total length of beach abrasion of 11,000 meters and an abrasion rate of around 4 meters per year. Meanwhile, only one location in the low category is Meskom Village, with an abrasive beach length of 500 meters and an abrasion rate of 2.5 meters per year. This data illustrates the vulnerability of the coast on Bengkalis Island, which requires serious attention in efforts to overcome and mitigate abrasion.

Table 2 describes changes in the coastline of Bengkalis Island from 1988 to 2020, focusing on three village locations that experienced abrasion [39]. In Sebauk Village, there was a decline in the coastline of 39.56 meters between 1988-2004 and 52.32 meters between 2004-2020, with an average rate of change of 2.87 meters per year. Meanwhile, Selat Baru Village experienced a decline in the coastline of 43.76 meters in the first period and 5.21 meters in the second period, with a rate of change of 1.53 meters per year. Lastly, Simpang Ayam Village showed a significant decline, namely 219 meters between 1988-2004 and 165.72 meters between 2004-2020, with a rate of change reaching 12.02 meters per year. These data reflect the serious impact of abrasion on Bengkalis Island, indicating the urgent need for shoreline protection and rehabilitation measures.

Table 1. Results of calculating the coastal vulnerability index for Bengkalis Island Beach

No.	Location	Subdistrict	Length of Abraded Beach (m)	Abrasion Rate per Year (m)	Abrasion Level
1	Muntai Village	Bantan	7.000	7	
2	Simpang Ayam Village	Bengkalis	6.000	7	
3	Pambang Village	Bantan	4.000	7	
4	Jangkang Village	Bantan	5.000	5	
Amount			**22.000**		**High**
5	Parit Lima Bantan Air Village	Bantan	4.000	4	
6	Bantan Tengah Village	Bantan	3.000	4	
7	Tg Kundu, Bantan Air Village	Bantan	2.000	4	
8	Selat Baru Village	Bantan	2.000	4	
Amount			**11.000**		**Medium**
9	Meskom Village	Bengkalis	500	2.5	
Amount			**500**		**Low**
Total Length of Abraded Beach			33.500		

Source: Environmental Service in Bengkalis Regency, 2022

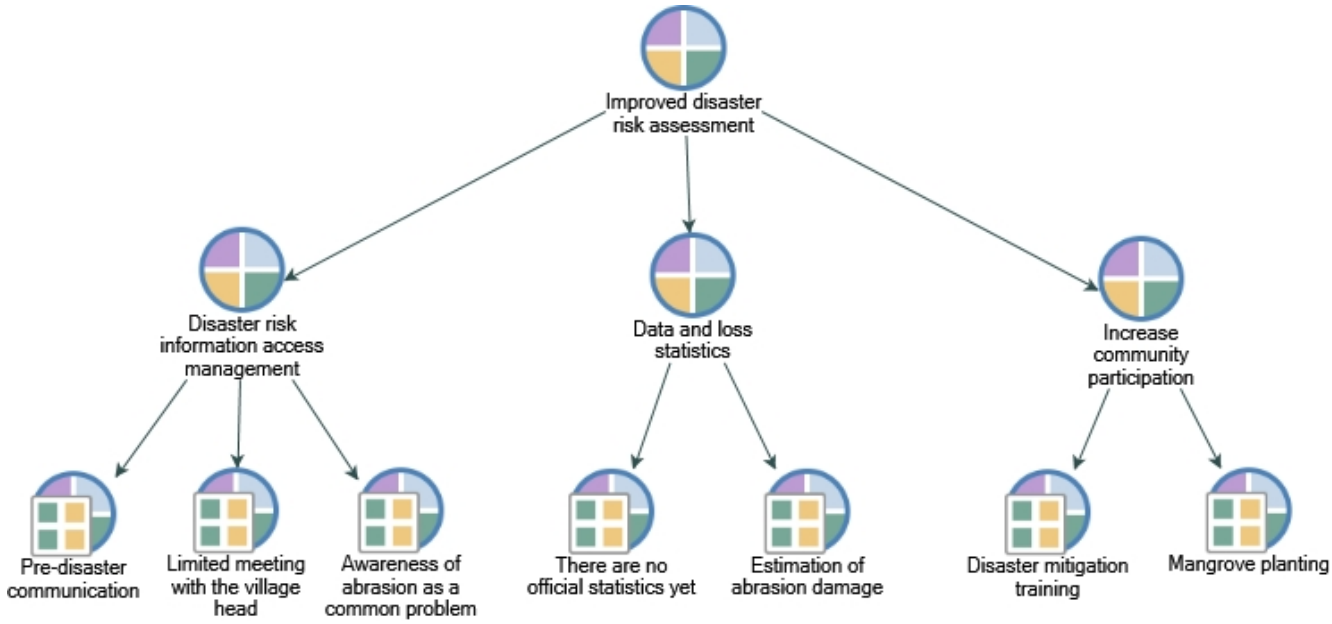

Figure 1. Abrasion management on Bengkalis Island is based on increased disaster risk assessment
Source: Processed by researchers with NVivo 12 Plus, 2024

Table 2. Changes in the coastline of Bengkalis Island (1988-2020) [39]

No.	Village Location	1988-2004 (m)	2004-2020 (m)	Rate of Change (m/year)
1	Sebauk	-39.56	-52.32	-2.87 m/year
2	Selat Baru	-43.76	-5.21	-1.53 m/year
3	Simpang Ayam	-219	-165.72	-12.02 m/year

The Sendai Framework contains 4 priorities, namely 1) increasing disaster risk assessment, 2) increasing institutional synergy and resilience in disaster risk governance, 3) strengthening investment in disaster risk management, and 4) increasing readiness for an effective response, which will be linked to abrasion handling that the Bengkalis Regency regional government has carried out. The Sendai Framework for handling abrasion on Bengkalis Island is based on increased disaster risk assessment, as seen in Figure 1.

Figure 1 is a visualization result of the thematic coding process using NVivo 12 Plus based on interview transcripts with key informants. This visualization illustrates three main themes in abrasion management on Bengkalis Island: disaster risk information access management, damage and loss statistics, and increasing community participation. Data were analyzed using the coding tree method with a bottom-up approach, where nodes and sub-nodes were formed based on the frequency and context of theme emergence in the informant's narrative.

Sendai Framework in handling abrasion on Bengkalis Island in the aspect of increasing institutional synergy and resilience in disaster risk management, as seen in Figure 2.

Figure 2 presents the results of a thematic mapping analysis conducted on qualitative data using NVivo 12 Plus, which identifies the relationships between main themes. Data were obtained from interviews and coded to identify correlations between institutional collaboration and the resilience of disaster risk governance, specifically in terms of institutional strengthening and improved service quality. This visualization was created using the Model Explorer feature to illustrate the logical flow of the impact of abrasion management policies on Bengkalis Island.

The Sendai Framework in handling abrasion on Bengkalis Island in terms of strengthening disaster risk management investment is shown in Figure 3.

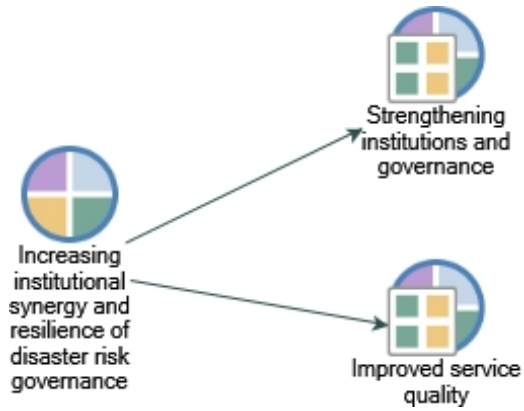

Figure 2. Handling abrasion on Bengkalis Island by increasing institutional synergy and resilience in disaster risk management
Source: Processed by researchers with NVivo 12 Plus, 2024

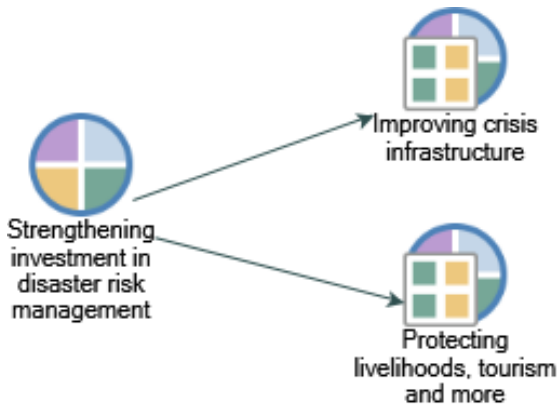

Figure 3. Handling abrasion on Bengkalis Island by strengthening investment in disaster risk management
Source: Processed by researchers with NVivo 12 Plus, 2024

Figure 3 illustrates the result of a qualitative analysis visualization using NVivo 12 Plus to depict the relationship between the main themes in abrasion management. Data obtained from interviews with key informants were analyzed and coded to show how investment in disaster risk management can improve crisis infrastructure and protect livelihoods and the tourism sector. This visualization uses the explorer model feature to display the cause-and-effect relationships that emerge in research findings related to abrasion management policies on Bengkalis Island.

The Sendai Framework for handling abrasion on Bengkalis Island in the aspect of increasing readiness for an effective response is seen in Figure 4.

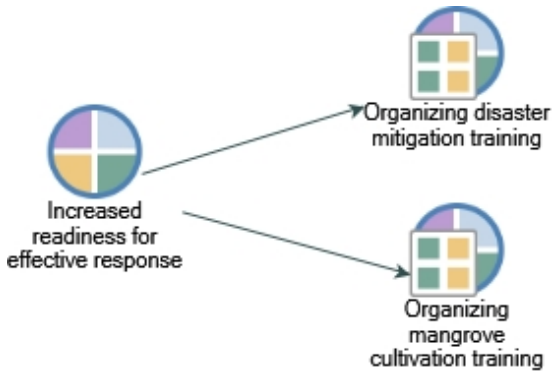

Figure 4. Handling abrasion on Bengkalis Island to increase readiness for an effective response
Source: Processed by researchers with NVivo 12 Plus, 2024

Figure 4 was created using the Model Explorer feature in NVivo 12 Plus to map the results of the thematic analysis of interview data. This visualization shows that increasing preparedness in responding to disasters effectively is closely related to the implementation of disaster mitigation training and mangrove cultivation training. The coding process was conducted to identify concrete actions taken by the community and government to strengthen their response capacity to sea abrasion on Bengkalis Island.

Figures 1-4 illustrate various aspects of abrasion management on Bengkalis Island based on the Sendai Framework. Figure 1 highlights the improvement of disaster risk assessment as a first step in identifying and analyzing potential abrasion threats. Figure 2 shows the importance of institutional synergy and governance resilience in strengthening collaboration between government and society in mitigation efforts. Figure 3 focuses on strengthening investment in disaster risk management, which is necessary to support infrastructure and sustainable recovery programs. Finally, Figure 4 emphasizes increasing preparedness for effective response, which is key to dealing with abrasion-related emergencies. These images reflect a holistic approach to addressing the abrasion problem on Bengkalis Island through an integrated framework.

4. DISCUSSION

The abrasion condition on Bengkalis Island is very worrying, with data showing varying levels of vulnerability in various locations and several villages experiencing extreme abrasion rates. Table 1 highlights four locations with high levels of vulnerability, while Table 2 reveals significant changes in the coastline from 1988 to 2020, especially in Simpang Ayam Village [39]. This shows that abrasion is not only a local environmental problem but also a serious threat to the socio-economic sustainability of coastal communities. Therefore, immediate mitigation and rehabilitation efforts are needed to protect the community and the environment from the negative impacts of abrasion and ensure the sustainability of the coastal ecosystem on Bengkalis Island.

Handling abrasion on Bengkalis Island through the Sendai Framework includes several important strategies to improve disaster risk assessment (Figure 1). One of them is managing access to disaster risk information, where the Bengkalis Regency government has realized the impact of abrasion and is trying to carry out pre-disaster communication to increase community awareness and participation. Through limited meetings with village heads, information about abrasion management was conveyed to the community in the hope that it would be well received. Collective awareness about abrasion as a common problem is important for involving various parties in mitigation and preventive action [10]. However, one of the challenges faced is the need for more official statistics regarding losses due to abrasion, which can result in inaccuracies in decision-making and budget planning.

The Bengkalis Regency Government has implemented a disaster mitigation and mangrove planting training program to increase community participation. This training program aims to increase community knowledge about disasters so that they are better prepared to face the risk of abrasion. Planting mangroves is also one of the actions taken to reduce the impact of abrasion, with financial support from the APBD (Regional Revenue and Expenditure Budget) and APBN (State Revenue and Expenditure Budget). However, this program faced natural obstacles that damaged mangrove forests. The community also showed initiative in dealing with abrasion creatively, such as using used tires as wave breakers. This shows the potential for collaboration between the community and government in disaster management, but further evaluation is needed to ensure that the methods used are environmentally friendly and effective [40].

Although the steps taken by the government and community in Bengkalis Regency show progress in dealing with abrasion, several weaknesses must be considered. The lack of valid and officially published statistical data can hinder the effectiveness of the policies taken [41, 42]. As an alternative to the lack of official statistical data, the use of technology such as remote sensing and spatial modelling can be used to monitor shoreline changes and estimate the impact of abrasion more accurately. This technology-based mitigation strategy can enhance the preparedness and effectiveness of responses to abrasion disasters on Bengkalis Island. In addition, although promising, communication between the government and the community still needs improvement to ensure all parties can receive messages related to abrasion management. For this reason, cooperation between government, academics and society must be further improved to create sustainable and evidence-based solutions so that abrasion management can be carried out comprehensively and in a targeted manner.

The increase in institutional synergy and resilience of disaster risk governance on Bengkalis Island in Figure 2 emphasizes the importance of collaboration between various stakeholders, both from regional and central government, in handling abrasion disaster risks. Each stakeholder has a significant role and must collaborate to form effective governance in mitigating and handling abrasion. The Regional Disaster Management Agency (BPBD) is committed to

providing high-quality information services and strives to improve the quality of disaster, rescue and evacuation services if necessary. The quality of this service must be supported by official and valid statistical data so that disaster management can be carried out appropriately. In addition, a clear legal basis, such as Law Number 11 of 2020 and Decree of the President of the Republic of Indonesia Number 6 of 2017, provides guidelines for each stakeholder to understand their authority and responsibility in handling abrasion disasters.

Although cooperation between institutions and stakeholders is very important, challenges in implementing institutional synergy exist, especially related to overlapping authority. Various regulations do not guarantee that collaboration can run without obstacles; instead, there is often confusion and a lack of coordination between different institutions. This can result in low efficiency in the use of resources and difficulties in achieving common goals in handling abrasion [43, 44]. Therefore, there is a need for an effective forum or consortium to coordinate programs and budgets in an integrated manner and ensure that each stakeholder understands their roles and responsibilities clearly. With concrete steps to overcome this problem, efforts to handle the risk of abrasion on Bengkalis Island could be improved, thereby reducing the effectiveness of the policies that have been established.

On the other hand, strengthening investment in disaster risk management on Bengkalis Island focuses on building disaster infrastructure (Figure 3), such as breakwaters and planting mangrove forests, to reduce the impact of abrasion. Disaster infrastructure such as breakwaters can function to protect coastal areas from abrasion, although the investment required is quite high. Meanwhile, planting mangroves on the shoreline is considered a more cost-efficient alternative, with its natural ability to retain sand affected by waves. However, the challenges in implementing the mangrove planting program must be considered, considering that, in several cases, not all societal elements understand these plants' positive impacts [45]. On the other hand, protecting people's livelihoods, especially in the agricultural and fisheries sectors, is an important aspect of this policy because abrasion has caused significant material losses and reduced the economic value of the affected land.

Although strengthening investment and building disaster infrastructure is important, several weaknesses in this approach need to be criticized. First, high reliance on physical development, such as breakwaters, can only be sustainable if balanced with ecosystem-based approaches, such as mangrove planting. If not done holistically, excessive focus on infrastructure can ignore the social and economic factors contributing to a community's vulnerability to abrasion. In addition, the lack of in-depth studies regarding the effectiveness of each method and the lack of collaboration between stakeholders can hamper the program's effectiveness and potentially worsen the conditions of affected communities. Therefore, an integrated approach is needed that involves all parties to overcome this challenge.

Increasing community readiness to face disaster risks on Bengkalis Island can also be achieved through disaster mitigation and mangrove cultivation training organized by the Bengkalis Regency BPBD (Figure 4). Disaster mitigation training aims to increase public knowledge regarding the steps needed when facing an emergency, which the Regency APBD funds. In addition, training on mangrove cultivation aims to introduce techniques for planting and maintaining mangroves, which have an important role in reducing the risk of abrasion. Collaboration with the Environmental Service also shows collaboration between stakeholders in handling abrasion, thereby strengthening comprehensive mitigation efforts.

However, while this training is a positive step, there are some drawbacks to be aware of. First, the success of training depends on community participation and understanding, which may vary, so delivery methods and training materials must be adapted to local characteristics to make them easier to understand. Additionally, episodic training without adequate follow-up can reduce its long-term effectiveness. Therefore, there is a need for ongoing programs to ensure that the knowledge gained remains internalized and applied in practice. In addition, these efforts must be balanced with supporting policies, such as incentives for communities active in mitigation, so that community involvement can be sustainable and more effective in dealing with disaster risks.

5. CONCLUSIONS

The Sendai Framework in dealing with marine abrasion disasters on Bengkalis Island provides a comprehensive approach to disaster risks. However, several criticisms need to be considered. One of the main criticisms is that although the framework emphasizes the importance of collaboration between stakeholders, more coordination often needs to be used, which hinders effective implementation. In addition, the lack of valid statistical data and accessibility of information regarding losses due to abrasion hinders informed decision-making. Efforts are needed to overcome this challenge, including creating an effective coordination forum, ensuring transparent distribution of information, and developing a more integrated and sustainable approach to disaster mitigation so that the strategies implemented can be truly effective in protecting the community and environment on Bengkalis Island. This includes designating a responsible local body, providing a dedicated budget, and establishing a clear implementation schedule.

To increase the effectiveness of dealing with marine abrasion disasters on Bengkalis Island, the government must take proactive steps to strengthen coordination between institutions and stakeholders. This can be done by forming a forum or consortium involving various parties, including society, academics and the private sector, to identify problems and formulate sustainable solutions collectively. In addition, the government needs to improve the system for collecting and publishing statistical data related to losses due to abrasion so that this information can be accessed and used in decision-making. Developing sustainable training programs for the community must also be considered so that knowledge regarding risk mitigation can be internalized and applied consistently. With these steps, it is hoped that tackling marine abrasion on Bengkalis Island can be more effective, sustainable and responsive to community needs and dynamic environmental conditions.

Limitations in this study include the possibility of bias in data collection, especially related to interviews conducted with key informants, who may have different perspectives and interests in abrasion management. In addition, the limited time of three months can reduce the depth of analysis and understanding of the overall abrasion phenomenon. The short study period of three months has the potential to introduce seasonal bias, which was not addressed in this study and should be acknowledged as a limitation, as well as a basis for

proposing future longitudinal studies. For future research, it is recommended that a more in-depth longitudinal study be carried out to obtain more comprehensive and continuous data. Future research could also consider involving more stakeholders, including private sector and civil society representatives, to gain a more holistic perspective on abrasion disaster management. In addition, developing more varied data collection methods, such as surveys or quantitative analysis, can help enrich research results and produce more effective recommendations for mitigation and adaptation policies.

ACKNOWLEDGMENT

The author would like to thank the Directorate of Research and Community Service, Universitas Islam Riau for providing financial assistance for this research. The author also gives thanks to the Regional Disaster and Management Agency of Bengkalis Regency, which has provided accurate data and information regarding the abrasion that occurred on Bengkalis Island.

REFERENCES

[1] Yan, X., Geng, S., Jiang, H., Sun, Z., Wang, N., Zhang, S., Yang, L., Wen, M. (2024). Redefining Benggang management: A novel integration of soil erosion and disaster risk assessments. Land, 13(5): 13050613. https://doi.org/10.3390/land13050613

[2] Freihardt, J., Buchs, R. (2024). Framing effects in disaster risk communication: The case of coastal erosion in the United States. Environmental Hazards, 23(3): 287-305. https://doi.org/10.1080/17477891.2023.2280691

[3] Akbari, M., Neamatollahi, E., Memarian, H., Alizadeh Noughani, M. (2023). Assessing impacts of floods disaster on soil erosion risk based on the RUSLE-GloSEM approach in western Iran. Natural Hazards, 117(2): 1689-1710. https://doi.org/10.1007/s11069-023-05925-y

[4] Ramadhan, C., Ruslanjari, D., Puspitasari, D., Indasari, G.D., Sandro, N. (2022). Coastal vulnerability assessment for community resilience on abrasion: Case of Bugel Coast, Kulon Progo Regency, Indonesia. ASEAN Journal on Science and Technology for Development, 39(1): 13-22. https://doi.org/10.29037/ajstd.715

[5] Sulistiyo, S., Amrullah, S., Putri, R.A.P., Ruslanjari, D. (2024). Mitigation and adaptation strategies of coastal community in Timbulsloko Village: Facing the impact of climate change. In Proceedings of the International Conference on Radioscience, Equatorial Atmospheric Science and Environment and Humanosphere Science, Indonesia, pp. 703-718. https://doi.org/10.1007/978-981-97-0740-9_63

[6] Qurani, I.Z., Fawzi, N.I., Fadilah, R., Kismorodati, W. (2021). Empowering fish-farmer through coastal field school: Towards sustainable aquaculture practice. IOP Conference Series: Earth and Environmental Science, 750(1): 12054. https://doi.org/10.1088/1755-1315/750/1/012054

[7] Ridwan, T.M., Ayob, A.F. (2024). Risk management of coastal ring roads to rate abrasion on the Lhokseumawe City. Journal of Advanced Research in Applied Sciences and Engineering Technology, 39(1): 168-182. https://doi.org/10.37934/araset.39.1.168182

[8] Stont, Z.I., Esiukova, E.E., Ulyanova, M.O. (2023). Clusters of cyclones and their effect on coast abrasion in Kaliningrad Region. Russian Journal of Earth Sciences, 23: 2205. https://doi.org/10.2205/2023ES000826

[9] Nurhayati, A.P., Raka Siwi, B.R.F., Muzoffar, C.A. (2020). Mangrove conservation in coastal areas Samas beach lagoon for controlling sea water abrasion. In 7th International Conference on Asian and Pacific Coasts, APAC 2013, Bali, Indonesia, pp. 1022-1024.

[10] Fathoni, S., Sutisna, S., Supriyatno, M. (2023). Community-based disaster risk reduction efforts in facing the threat of abrasion disasters at Bungin Beach, Bekasi Regency during the COVID-19 pandemic. IOP Conference Series: Earth and Environmental Science, 1173(1): 12068. https://doi.org/10.1088/1755-1315/1173/1/012068

[11] Baynes, E.R.C., Attal, M., Niedermann, S., Kirstein, L.A., Dugmore, A.J., Naylor, M. (2015). Erosion during extreme flood events dominates Holocene canyon evolution in northeast Iceland. Proceedings of the National Academy of Sciences of the United States of America, 112(8): 2355-2360. https://doi.org/10.1073/pnas.1415443112

[12] Sarker, M.N.I., Alam, G.M.M., Firdaus, R.B.R., Biswas, J.C., et al. (2022). Assessment of flood vulnerability of riverine island community using a composite flood vulnerability index. International Journal of Disaster Risk Reduction, 82: 103306. https://doi.org/10.1016/j.ijdrr.2022.103306

[13] Sujadmiko, B., Meidiantama, R. (2022). Vertical conflict on sea sand mining activities in Lampung; Law enforcement and sociological approach. Administrative and Environmental Law Review, 3(2): 107-118. https://doi.org/10.25041/aelr.v3i2.2681

[14] Kwon, Y.M., Moon, J.H., Cho, G.C., Kim, Y.U., Chang, I. (2023). Xanthan gum biopolymer-based soil treatment as a construction material to mitigate internal erosion of earthen embankment: A field-scale. Construction and Building Materials, 389: 131716. https://doi.org/10.1016/j.conbuildmat.2023.131716

[15] Zhao, C., Mou, W., Liu, J., Li, C., Lei, L., Ta, F., Lai, S., Feng, Y., Zhou, Z. (2024). Vegetation restoration restrains rill erosion on slag heaps in high-altitude goldfields. Science of the Total Environment, 912: 169528. https://doi.org/10.1016/j.scitotenv.2023.169528

[16] Stefanidis, S.P., Proutsos, N.D., Solomou, A.D., Michopoulos, P., Bourletsikas, A., Tigkas, D., Spalevic, V., Kader, S. (2024). Spatiotemporal monitoring of post-fire soil erosion rates using earth observation (EO) data and cloud computing. Natural Hazards, 121: 2873-2894. https://doi.org/10.1007/s11069-024-06907-4

[17] Gerwing, T.G., Cox, K. (2017). Erosion of trust in government consultation will impede the creation of environmental policy. Marine Policy, 83: 126-127. https://doi.org/10.1016/j.marpol.2017.06.005

[18] Arnalds, O., Barkarson, B.H. (2003). Soil erosion and land use policy in Iceland in relation to sheep grazing and government subsidies. Environmental Science and Policy, 6(1): 105-113. https://doi.org/10.1016/S1462-9011(02)00115-6

[19] Nguyen, N.M., Van, D.D., Le, D.T., Cong, S.D., et al. (2023). Experimental and numerical modeling of pile-

rock breakwater gap arrangement for optimal coastal erosion protection in deltaic coasts. Ocean Engineering, 280: 114625. https://doi.org/10.1016/j.oceaneng.2023.114625
[20] Khor, C.H., Yap, S.P., Leong, G.W. (2024). Investigation of piping erosion in embankment dams with downstream filters. Journal of Geotechnical and Geoenvironmental Engineering, 150(6): 11743. https://doi.org/10.1061/jggefk.gteng-11743
[21] Zhou, L., Ding, G. (2021). Seismic response of reinforced retaining walls with saturated calcareous sand backfill subjected to acid rain erosion. Journal of Materials in Civil Engineering, 33(8): 5533. https://doi.org/10.1061/(asce)mt.1943-5533.0003856
[22] Wang, H., Xie, M., Chen, O., Zhou, Z., Cao, H., Wei, W. (2024). Investigation on the soil resistance to wave-induced lateral erosion under different mangrove forests. Journal of Sea Research, 200: 102517. https://doi.org/10.1016/j.seares.2024.102517
[23] Thomson, D.P., Dee, S., Doropoulos, C., Orr, M., Wilson, S.K., Hoey, A.S. (2024). High rates of erosion on a wave-exposed fringing coral reef. Limnology and Oceanography, 69(6): 1439-1449. https://doi.org/10.1002/lno.12586
[24] Friedrich, D. (2016). Teach for all, public-private partnerships, and the erosion of the public in education. In World Yearbook of Education 2016: The Global Education Industry. Routledge, pp. 180-194.
[25] Dorn, T., Day, M. (2024). Spatial variability in aeolian abrasion: Ibex Dune Field, Death Valley National Park. Sedimentology, 72(1): 258-274. https://doi.org/10.1111/sed.13233
[26] Rusadi, S., Mulyawan, R., Suwaryo, U., Yuningsih, N.Y. (2024). Implementing good environmental governance to manage coastal abrasion in Bengkalis Regency, Indonesia. International Journal of Sustainable Development and Planning, 19(5): 1911-1919. https://doi.org/10.18280/ijsdp.190529
[27] Irmawan, M., Imaaduddiin, M.H., Alam, R.R.R., Refani, A.N., Aini, A.N. (2024). Hydrodynamic analysis-based modeling of coastal abrasion prevention (Case study: Pulau Baai Port, Bengkulu). Applied Sciences (Switzerland), 14(2): 14020940. https://doi.org/10.3390/app14020940
[28] Sudirman, N., Salim, H.L., Rustam, A., Ati, R.N.A., Hernina, R., Marini, Y., Suryono, D.D. (2023). Assessment of mangrove ecosystem potential in Bontang Regency-East Kalimantan to reduce abrasion. IOP Conference Series: Earth and Environmental Science, 1148(1): 12041. https://doi.org/10.1088/1755-1315/1148/1/012041
[29] Akbar, A., Rasyid, B., Padjung, R., Aminah. (2024). Erosion hazard level in Jenelata Watershed, Gowa Regency, South Sulawesi, Indonesia based on RUSLE Model. Agrivita, 46(1): 104-113. https://doi.org/10.17503/agrivita.v46i1.4339
[30] Aldiansyah, S., Wardani, F. (2024). Spatiotemporal dynamic of soil erosion in the Roraya River Basin based on RUSLE model and Google Earth Engine. Journal of Hydroinformatics, 26(6): 1273-1294. https://doi.org/10.2166/hydro.2024.219
[31] Tampubolon, H. (2022). Shoreline change cause of abrasion in Bantan District Bengkalis Island as the Outstanding Beach Area. In Lecture Notes in Civil Engineering. Springer, Singapore, pp. 35-48. https://doi.org/10.1007/978-981-16-7949-0_4
[32] Adu-Gyamfi, B., Ariyaningsih, A., Zuquan, H., Yamazawa, N., Kato, A., Shaw, R. (2024). Reflections on science, technology and innovation on the aspirations of the Sendai framework for disaster risk reduction. International Journal of Disaster Resilience in the Built Environment, 15(2): 289-302. https://doi.org/10.1108/IJDRBE-06-2022-0062
[33] Nekoei-Moghadam, M., Moradi, S.M., Tavan, A. (2024). How can the Sendai framework be implemented for disaster risk reduction and sustainable development? A qualitative study in Iran. Globalization and Health, 20(1): 12992. https://doi.org/10.1186/s12992-024-01028-w
[34] Kelman, I. (2015). Climate change and the Sendai framework for disaster risk reduction. International Journal of Disaster Risk Science, 6(2): 117-127. https://doi.org/10.1007/s13753-015-0046-5
[35] Faivre, N., Sgobbi, A., Happaerts, S., Raynal, J., Schmidt, L. (2018). Translating the Sendai Framework into action: The EU approach to ecosystem-based disaster risk reduction. International Journal of Disaster Risk Reduction, 32: 4-10. https://doi.org/10.1016/j.ijdrr.2017.12.015
[36] Gunanda, A., Koestoer, R.H.S. (2023). Evaluation of flood disaster management planning: A comparative method for Bostwana and Indonesia. ASEAN Natural Disaster Mitigation and Education Journal, 1(1): 12-19. https://doi.org/10.61511/andmej.v1i1.2023.134
[37] Nehren, U., Ho Dac Thai, H., Trung, N.D., Raedig, C., Alfonso, S. (2017). Sand dunes and mangroves for disaster risk reduction and climate change adaptation in the coastal zone of Quang Nam Province, Vietnam. In: Nauditt, A., Ribbe, L. (eds) Land Use and Climate Change Interactions in Central Vietnam. Water Resources Development and Management. Springer, Singapore, pp. 201-222. https://doi.org/10.1007/978-981-10-2624-9_13
[38] Langkulsen, U., Rwodzi, D.T., Cheewinsiriwat, P., Nakhapakorn, K., Moses, C. (2022). Socio-economic resilience to floods in coastal areas of Thailand. International Journal of Environmental Research and Public Health, 19(12): 1-13. https://doi.org/10.3390/ijerph19127316
[39] Nabilla, L.M., Mubarak, M., Elizal, E. (2021). Analysis of coastline changes on the potential of mangrove forests on Bengkalis Island, Riau Province. Asian Journal of Aquatic Sciences, 4(2): 163-170. https://doi.org/10.31258/ajoas.4.2.163-170
[40] Nurkaidah, Anas, A., Baharuddin, T. (2024). Implementation of environmental policies on the development of a new capital city in Indonesia. Cogent Social Sciences, 10(1): 2297764. https://doi.org/10.1080/23311886.2023.2297764
[41] Wang, D., Mei, J. (2024). An advanced review of climate change mitigation policies in the United States. Resources, Conservation and Recycling, 208: 107718. https://doi.org/10.1016/j.resconrec.2024.107718
[42] Soon, J., Lee, D.W., Choi, G.R., Kim, K.J., Bahn, S. (2022). Identification of gait and personal factors associated with shoe abrasion patterns. International Journal of Environmental Research and Public Health, 19(19): 3390. https://doi.org/10.3390/ijerph191912558
[43] Bertoni, D., Sarti, G., Grottoli, E., Ciavola, P., Pozzebon,

A., Domokos, G., Novák-Szabó, T. (2016). Impressive abrasion rates of marked pebbles on a coarse-clastic beach within a 13-month timespan. Marine Geology, 381: 175-180. https://doi.org/10.1016/j.margeo.2016.09.010

[44] Omoding, N., Cunningham, L.S., Lane-Serff, G.F., Omer, M., Farrington, B. (2023). Field investigation into abrasion of concrete at a coastal stepped revetment: A U.K. case study. Journal of Marine Science and Engineering, 11(6): 1145. https://doi.org/10.3390/jmse11061145

[45] Al Safar, M.R., Hasanuddin, T., Listiana, I. (2023). Analysis of perception and participation of coastal community in the utilization of mangrove plants as abrasion prevention in East Lampung. AIP Conference Proceedings, 2621(1): 142488. https://doi.org/10.1063/5.0142488