

The Role of Local Government and Environmental Management in Managing Tidal Floods in Bintan Regency

Aldy Wiguna¹, Rudi Subiyakto²

Universitas Maritim Raja Ali Haji^{1,2}

Corespondence: aldywiguna2521@gmail.com¹

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ABSTRACT

Indonesia is highly vulnerable to natural disasters, with tidal floods being a significant concern in Bintan Regency due to its exposure to sea tides and extreme weather events. The local government's role and environmental management strategies are crucial in mitigating these risks. This research seeks to evaluate these aspects by focusing on the measures implemented by Bintan Regency to manage tidal floods. The study employs a qualitative approach, relying on literature reviews to collect data from various sources such as scientific journals, books, research reports, and other relevant documents. This method provides a comprehensive understanding of the current practices and effectiveness of flood management and environmental management strategies in Bintan Regency. The research findings indicate that the Bintan Regency local government has undertaken significant initiatives to reduce tidal flood risks. These initiatives include spatial planning that integrates disaster risk considerations, the development of flood management infrastructure, and community education programs aimed at increasing preparedness. The effective implementation of environmental management practices, including the use of advanced technology for monitoring and evaluation, has been instrumental in these efforts. The local government's approach reflects a proactive stance in addressing the challenges posed by tidal floods, emphasizing both preventative measures and responsive strategies. The study concludes that a holistic and sustainable approach is essential for effective tidal flood management. The integration of comprehensive spatial planning, infrastructure development, community engagement, and modern technology forms a robust framework for disaster mitigation.

Keyword: Role, Local Government, Tidal Floods, Disaster Mitigation

INTRODUCTION

Natural disasters include natural phenomena such as earthquakes, tsunamis, volcanic eruptions, floods, landslides, droughts, and storms. As an archipelagic country in the Pacific ring of fire, Indonesia is very vulnerable to various natural disasters. Due to its location between three large tectonic plates: the Eurasian Plate, the Indo-Australian Plate, and the Pacific Plate, Indonesia frequently experiences earthquakes and volcanic eruptions (Kirschenbaum, 2004; Wang et al., 2020). Apart from that, the tropical climate and diverse geographical conditions also make Indonesia vulnerable to floods, landslides and droughts (Aldunce et al., 2021; Rus et al., 2018). According to the National Disaster Management Agency, disaster management includes prevention and reconstruction before, during and after a disaster because disasters often affect communities (Mahadiansar et al., 2023; Setiawan & Mahadiansar, 2020).

Disasters can generally be divided into three main phases: pre-disaster, when the disaster occurs, and post-disaster. All three are included in joint disaster management efforts.

Disaster mitigation is a series of efforts made to reduce or minimize the negative impacts caused by natural disasters. This mitigation includes coordinated and systematic preventive, preparation and response measures. In the Indonesian context, disaster mitigation is very crucial considering the high frequency and intensity of disasters (Weichselgartner, 2001). Disaster mitigation efforts can be divided into two main categories, structural and non-structural. Structural mitigation involves building infrastructure that is resilient to disasters, such as building embankments to prevent flooding, earthquake-resistant houses, and early warning systems for tsunamis (Dartanto, 2022; Fuady et al., 2021). Meanwhile, non-structural mitigation includes educating the public about disaster preparedness, developing policies and regulations that support disaster risk reduction, as well as strengthening the capacity of institutions and communities in dealing with disasters (Boudreaux et al., 2023; Ishiwatari et al., 2020).

The Indonesian government has developed various policies and programs to increase disaster mitigation capacity. The National Disaster Management Agency (BNPB) was established as the institution responsible for coordinating disaster management at the national level. In addition, programs such as Disaster Resilient Villages and Disaster Safe Schools aim to increase the preparedness and resilience of local communities to disasters. The importance of disaster mitigation is also recognized in various international frameworks such as the Sendai Framework for Disaster Risk Reduction 2015-2030, which emphasizes the importance of reducing disaster risk through a holistic and inclusive approach. In disaster mitigation efforts, this framework underlines that government, the private sector and civil society must work together (Kusumastuti et al., 2014; Zamroni et al., 2020).

This collaboration relies largely on social network management, which helps stakeholders communicate with each other (Kapucu et al., 2010; Raschky, 2008). With effective mitigation efforts, it is hoped that the negative impacts of natural disasters can be minimized, so that communities can be better prepared and resilient in facing various disaster threats. This effort not only requires an active role from the government and related institutions, but also participation and awareness from all levels of society. Disaster preparedness education and training is key in building a community that is resilient and responsive to natural disasters (Kusumasari & Alam, 2012; Yulianto et al., 2021).

In order to achieve optimal disaster mitigation, an integrated and sustainable approach is needed, involving various stakeholders, and supported by accurate data and research. Only in this way can people live more safely and be protected from the threat of natural disasters that continue to lurk. Natural disasters not only cause immediate impacts such as physical damage and loss of life, but also long-term impacts such as economic disruption, loss of livelihood and psychological disorders for victims. Therefore, it is important to understand the characteristics and causes of natural disasters as a first step in disaster mitigation efforts (Liu et al., 2021; Oktari et al., 2020).

Bintan Regency, as one of the island regions in the Riau Islands Province, often faces significant challenges related to the tidal flood phenomenon. Tidal floods, which are caused by a combination of sea tides and extreme weather conditions, often cause damage to infrastructure, disruption of economic activities, and have an impact on community welfare. This phenomenon is not only a seasonal threat but also shows the urgency for comprehensive and sustainable treatment (Coppola, 2015; Toya & Skidmore, 2007). The impact of tidal floods is very significant, both from a social and economic perspective.

Socially, tidal floods cause major disruption to people's daily lives, ranging from disruption of household activities to disruption of public services such as education and health. From an economic perspective, tidal floods cause major losses, especially in key sectors such

as fisheries, tourism and trade. Vital infrastructure such as roads, bridges and other public facilities often suffer damage which requires large costs to repair and restore. The height of the tidal flood is the same as the height of the sea tide, and this flood will recede when the sea water recedes. Sea level height can change according to changes in tides. In this way, we can estimate how large an area will be inundated by tidal floods at a certain time.

Table 1. Total Regional Height Above Sea Level According to District in Bintan Regency

No.	District	Height Above Sea Level (masl)
1	Teluk Bintan	10
2	North Bintan	20
3	Teluk Sebong	20
4	Seri Kuala Lobam	5
5	East Bintan	25
6	Gunung Kijang	3
7	Mantang	4
8	Coastal Bintan	30
9	Toapaya	25
10	Tambelan	3

Source: Bintan Regency in Figures 2022

The height of areas in Bintan Regency varies, with a maximum height of 30 meters above sea level (masl) and a minimum of 3 meters above sea level. This variation affects the region's vulnerability to tidal floods, where areas with lower elevations are more vulnerable to the impact. Districts with a height below 10 meters above sea level such as Gunung Kijang, Seri Kuala Lobam, Mantang, and Tambelan are the most vulnerable to tidal floods. Mitigation efforts such as raising embankments, better drainage systems, and evacuation measures should be prioritized in these areas.

Districts with altitudes between 10 meters above sea level and 20 meters above sea level such as Bintan Bay, North Bintan and Sebong Bay have a moderate risk. Although the risk is not as high as in low-altitude areas, preventive measures are still necessary. Districts with a height of 25 meters above sea level such as East Bintan, Pesisir Bintan and Toapaya are relatively safer from tidal floods. However, monitoring and management efforts remain essential to ensure safety. Low-altitude areas in Bintan Regency are very vulnerable to tidal floods and require special attention in terms of mitigation and infrastructure. The height of the area is an important factor in determining disaster management priorities, where lower areas require more immediate and intensive action.

Tidal floods in Bintan Regency not only threaten infrastructure and property, but also disrupt the daily lives of local residents. The impact includes damage to roads, houses, public facilities, to agricultural land and ponds. Apart from that, tidal floods also have the potential to cause health problems due to polluted water and spread disease. Therefore, tidal flood management is a very important issue for local governments to ensure the safety and welfare of the community. Local governments have a very important role in managing natural disasters such as tidal floods. This role includes formulating policies, implementing mitigation programs, and coordinating with various parties to improve disaster preparedness and response. These efforts require a holistic approach, involving good spatial planning, building flood defense infrastructure, and educating the public regarding preventive and adaptation measures.

According to the 2018 Indonesian Disaster Risk Index calculations, disaster threats in Bintan Regency include (1) floods, (2) extreme waves and abrasion, (3) extreme weather, (4) drought, (5) epidemics and disease outbreaks, and (6)) forest and land fires. Bintan Regency's

IRBI score is 132.40, which is in the medium risk category, and the highest among the six districts/provinces. Tornadoes, forest and plantation fires, drought during the dry season, floods during the rainy season, and tidal waves are some of the disasters that can occur in Bintan Regency. However, Regional Regulation Number 1 of 2020 concerning Bintan Regency Regional Spatial Planning (RTRW) 2020–2040, Article 27 states that disaster-prone areas, namely areas prone to tidal waves, tornadoes and abrasion, have a low level of vulnerability and impact. (Harsoyo, 2022)

Implementing effective environmental management is one of the main strategies in managing tidal floods. Ecosystem-based approaches, such as mangrove conservation and rehabilitation, as well as the use of environmentally friendly technology, such as environmentally sound drainage systems, are some of the steps that can be taken to reduce the impact of tidal floods. This research aims to examine the role of local government and the implementation of environmental management in managing tidal floods in Bintan Regency.

METHODOLOGY

This research adopts a qualitative approach, specifically utilizing a literature study method to gather and analyze data (Creswell & Creswell, 2018). The data for this study were meticulously collected from a wide array of relevant literature sources. These sources encompass scientific journals, books, research reports, and other pertinent documents, as outlined (Moleong, 2012). Additionally, the research involves a thorough analysis of various policy and program documents that are relevant to the subject matter. The primary objective of this data collection and analysis is to gain a comprehensive understanding of the role that local governments play in the management of tidal floods, as well as to evaluate the implementation of environmental management strategies in this context.

The data analysis was conducted in a descriptive manner, aiming to elucidate the intricate dynamics and the effectiveness of local government interventions in managing tidal floods. Through this descriptive analysis, the study seeks to identify key factors and best practices that can enhance the capacity of local governments in this critical area of environmental management (Robins et al., 2011). Ultimately, the findings of this research are intended to culminate in the formulation of policy recommendations. These recommendations are expected to be of practical use to local governments and other stakeholders, providing them with actionable insights and strategies to improve their capacity for managing tidal floods more effectively. By contributing to the body of knowledge in this field, the research aims to support the development of more robust and resilient environmental management frameworks that can better address the challenges posed by tidal floods.

RESULTS AND DISCUSSION

The coastal areas of Bintan Regency have been significantly impacted by tidal flooding, affecting numerous communities across various districts. In Bintan Utara, the town of Tanjungban Kota has experienced the highest impact, with 359 households affected. Additionally, Tanjung Uban Selatan and Tanjung Uban Utara each have three affected households. Moving to Mantang, the villages of Mantang Besar, Mantang Baru, Mantang Lama, and Dendun have seen 75, 23, 91, and 79 households affected, respectively. In Bintan Pesisir, the villages of Numbing, Air Gelubi, Kelong, and Mapur have 53, 59, 49, and 3 households affected, respectively.

Further impacts are noted in Sri Kuala Lobam, where Teluk Sasah, Busung, Kuala Sempang, Tanjung Permai, and Teluk Lobam have 30, 47, 28, 1, and 8 households affected, respectively. In Teluk Bintan, the villages of Penaga, Tembeling, Pengujan, Pangkil, and Bintan Buyu have seen 55, 101, 72, 2, and 69 households affected, respectively. Teluk Seborg has

also experienced flooding, with the villages of Pengudang, Sri Bintan, Ekan Aculai, and Kota Baru reporting 5, 26, 17, and 13 affected households, respectively.

In Gunung Kijang, the villages of Malang Rapat and Kawal have 19 and 28 households affected, respectively. The district of Tambelan has reported minimal impact, with the villages of Batu Lepuk and Kampung Melayu each having one household affected. Lastly, in Bintan Timur, the areas of Kijang Kota, Sei Enam, Sei Lekop, and Gunung Lengkuas have seen 199, 32, 98, and 4 households affected, respectively. These figures highlight the widespread impact of tidal flooding across the coastal regions of Bintan, as reported by the Bintan Regency Regional Disaster Management Agency in 2023.

Tidal floods have had a significant impact on certain areas in Bintan Regency, with North Bintan, East Bintan and Teluk Bintan Districts being the most affected areas. The total number of heads of families (KK) affected in all sub-districts reached 1653 families. North Bintan is the most affected area, with the largest number of affected families, namely 365 families. Of this number, the majority are in Tanjungban Kota Subdistrict (359 families), indicating that this area requires special attention in tidal flood mitigation. East Bintan has the second largest number of affected families with 333 families, especially in Kijang Kota sub-district (199 families). Data shows that Kijang City also requires immediate flood management measures. Teluk Bintan is in third position with 299 families affected.

Tembeling sub-district is the most affected area in this sub-district with 101 families. Mantang has 268 affected families, with the largest number in Mantang Lama (91 families) and Dendun (79 families) sub-districts. Bintan Pesisir recorded 164 families affected, with Air Gelubi Village as the most affected area (59 families). Sri Kuala Lobam was affected with 114 families, with Busung (47 families) as the sub-district that needed assistance the most. Sebang Bay recorded 61 families affected, with Sri Bintan (26 families) being the highest. Tambelan is the sub-district with the least impact, only 2 families were affected in Batu Lepuk and Kampung Melayu, 1 family each.

Based on the data, mitigation and assistance efforts must be focused first on the Districts of North Bintan, East Bintan and Teluk Bintan. Further mapping is needed to understand the topographic details and infrastructure conditions that make these areas more vulnerable to tidal flooding. The role of regional government in managing tidal floods is very crucial considering that regional government has direct authority and responsibility for the development and welfare of local communities. In Bintan Regency, the local government has taken various steps to overcome the problem of tidal flooding, both through preventive and responsive efforts.

1. Tidal Flood Management Strategies in Bintan Regency
 - a. Planning and Policy

The Bintan Regency Government has prepared various plans and policies that focus on reducing the risk of tidal floods. The Bintan Regency Regional Spatial Planning (RTRW) includes land use arrangements that take into account the risk of tidal flooding, including zones where no development is permitted. Apart from that, local policies that support sustainable development and environmental management have also been implemented to minimize the impact of tidal floods. The Bintan Regency Regional Spatial Planning Plan (RTRW) is the main instrument in regulating land use that takes into account the risk of tidal floods. This RTRW not only regulates physical development such as housing and infrastructure, but also determines certain zones where development cannot be carried out due to the high potential risk of disaster. This approach ensures that regional development is carried out by considering aspects of environmental security and sustainability.

Apart from RTRW, the Bintan Regency government also implements local policies that support sustainable development. This policy not only aims for sustainable economic growth,

but also takes into account environmental impacts including the potential risk of tidal floods. These steps include integrated water management, preserving natural vegetation, and developing green infrastructure to absorb rainwater. Thus, tidal flood risk mitigation efforts are integrated into the long-term development strategy of Bintan Regency.

Environmental management is also an important focus in Bintan Regency government policy. These efforts include controlling land use, monitoring water and soil quality, and increasing awareness of the importance of environmental conservation. This policy not only aims to protect the environment in general, but also to reduce vulnerability to tidal floods by minimizing natural changes that could worsen the situation. The Bintan Regency RTRW has regulated land use by considering the risk of tidal floods. Areas that are prone to tidal flooding, such as North Bintan and East Bintan, which have a high number of affected families, must be included in conservation zones or zones where development is restricted. Areas such as Bintan Pesisir and Gunung Kijang sub-districts, which are at low elevations, were identified as conservation zones to reduce the risk of tidal flooding. This approach helps reduce development in flood-prone areas and maintains ecosystem balance.

Implementation of green infrastructure in affected areas, such as the construction of city parks, water catchment areas and natural vegetation, helps absorb rainwater and reduce waterlogging. For example, in East Bintan, which has a number of families significantly affected. Local policies that support integrated water management ensure that the drainage system is able to accommodate and convey water efficiently. Areas such as Tanjungban City in North Bintan can benefit from improvements and maintenance of good drainage systems.

Determining no-building zones and monitoring land use in flood-prone areas such as Sri Kuala Lobam, which is at a low altitude (5 meters above sea level), helps reduce the risk of tidal floods. The Bintan Regency Government carries out regular monitoring of water and soil quality to ensure that the environment is maintained. This is important for areas with a high number of affected families such as Tanjungban City in North Bintan. Local policies that support sustainable development and environmental management are also implemented, including the development of green infrastructure and integrated water management. It is hoped that this effort can reduce the impact of tidal floods, especially in areas with a high number of affected families. The success of this policy is highly dependent on proper implementation and cooperation of all relevant parties, including government, society and the private sector

b. Infrastructure development

One of the structural efforts undertaken is the construction and improvement of flood prevention infrastructure. A better drainage system can reduce the risk of tidal floods. Maintenance of the drainage system is carried out regularly to ensure smooth water flow. Improving the drainage system is also the main focus in dealing with tidal floods. A good and regular drainage system ensures that rainwater and tidal water that enters land can be channeled quickly and efficiently to the sea or nearby rivers. The local government has repaired and built new drainage channels in various areas prone to tidal flooding, to reduce waterlogging and speed up the flow of water out. Routine maintenance of the drainage system is also an important step in dealing with tidal floods. Maintenance includes cleaning drainage channels, repairing damage, and regular inspections to ensure that the drainage system is functioning properly.

c. Community Education and Preparedness

Regional governments also play a role in increasing community awareness and preparedness for tidal floods. Educational programs through outreach and disaster preparedness training are often held to provide understanding to the public about the actions

that must be taken when a tidal flood occurs. The formation of disaster resilient communities in various villages also aims to increase active community participation in flood management. Local governments often hold education and outreach programs about tidal floods as an effort to increase public awareness. This program includes education about the causes of tidal floods, danger signs, and steps that must be taken to reduce the risk and deal with tidal floods. Through intensive outreach, the regional government hopes to create a better understanding among the community of the urgency and importance of disaster preparedness.

In general, people take attitudes that are appropriate to the problems occurring in their environment when facing changes in environmental conditions. This attitude is closely related to how society views disasters. Apart from outreach, disaster preparedness training is also an integral part of local government strategies in dealing with tidal floods. This training not only teaches practical skills such as emergency evacuation and first aid, but also forms a prepared mentality and attitude among the community. By increasing skills and knowledge about appropriate actions when a disaster occurs, it is hoped that the community can be better prepared to face emergency situations and reduce the negative impacts that may occur.

The formation of disaster resilient communities in various villages is a long-term regional government strategy in building local resilience to tidal floods. This disaster resilient community aims to organize local communities in mitigation and response efforts to disasters. They are trained to identify risks, develop emergency plans, and conduct disaster response simulations on a regular basis. In this way, communities can act independently but coordinated when a disaster occurs, speeding up the response process and reducing the losses incurred. These strategies have a significant positive impact on society.

Increasing awareness of the risk of tidal floods and knowledge about the actions that must be taken can reduce the level of community vulnerability to disasters. Active participation in disaster resilient communities also increases the sense of belonging and social cohesion among residents, strengthening solidarity and cooperation in facing crises. Educational programs regarding the dangers of tidal flooding and mitigation measures must be intensified. This includes direct outreach, use of social media, and information campaigns in vulnerable areas such as Tanjunguban City in North Bintan, which has the highest number of affected families (359).

Training involving tidal flood simulations can help communities prepare for emergency situations. In areas with a high level of risk such as Kijang City in East Bintan, which has 199 affected families, this training is very important. Implementation of an early warning system for tidal floods in frequently affected areas. This can be done through the installation of tidal sensors and rainfall gauges in areas such as Numbing in Coastal Bintan and Sasah Bay in Sri Kuala Lobam. Preparation of a clear and coordinated evacuation plan. In areas such as Tembeling in Bintan Bay, with 101 families affected, efficient evacuation plans are essential to reduce the risk of loss of life.

Formation of community groups that are trained and ready to handle emergency situations in each village/sub-district, such as Mantang Besar in Mantang District with 75 affected families, this group can function as the spearhead in disaster management. Involving non-governmental organizations and local institutions in efforts to increase tidal flood preparedness and mitigation. In areas such as Sebong Bay, which has several villages with a small but distributed number of affected families, this collaboration can increase effectiveness. Building infrastructure that is resistant to flooding, such as houses on stilts in areas frequently affected by tidal floods.

In areas such as Tanjunguban City, this can significantly reduce the impact of flooding. Encourage the planting of mangroves and other natural vegetation in coastal areas to reduce the impact of tidal floods. Areas like Kelong in Coastal Bintan can benefit greatly from this

program. Community education and preparedness are the keys to dealing with tidal floods in Bintan Regency. Awareness raising programs and disaster management training must be increased, especially in areas with a high number of affected families. An early warning system and clear evacuation plans can reduce the risk and impact of tidal floods. In addition, community empowerment and development of flood-resistant infrastructure and environmental adaptation will support community resilience to tidal floods. Collaboration between government, communities, and local institutions is critical to ensuring the success of these efforts.

2. Integrated Strategies for Tidal Flood Management in Bintan Regency

a. Monitoring and Evaluation

The local government of Bintan Regency has adopted modern technology for monitoring areas prone to tidal flooding, such as Geographic Information Systems (GIS) and automatic sensors. Data collected through this technology is used to evaluate and improve policies and actions to deal with tidal floods. Periodic evaluations are also carried out to assess the effectiveness of existing programs and design better strategies in the future. This analysis will discuss the importance of routine monitoring and evaluation in tidal flood mitigation efforts in Bintan Regency.

The local government of Bintan Regency uses modern monitoring technology such as Geographic Information Systems (GIS) and automatic sensors to monitor areas prone to tidal flooding. GIS technology allows detailed and real-time mapping of areas, so that local governments can monitor changes in environmental conditions that can affect the risk of tidal floods. Automatic sensors are installed at various strategic locations to measure environmental parameters such as water level, rainfall and soil moisture. This automatically collected data provides accurate and fast information, which is very important for timely decision making in tidal flood management.

Data collected through this monitoring technology is used by local governments to evaluate and improve policies and actions to deal with tidal floods. Data analysis helps in identifying areas most vulnerable to tidal flooding and assessing the effectiveness of the actions taken. Governments can use this information to improve existing infrastructure, plan new development, and adjust policies as needed to increase protection against tidal floods. Periodic evaluation is an important part of the tidal flood management strategy in Bintan Regency. This evaluation involves assessing the programs and policies that have been implemented, with a focus on their effectiveness, efficiency and impact on society. Regular evaluation allows local governments to identify the strengths and weaknesses of existing programs, as well as develop new, more effective strategies. By conducting regular evaluations, local governments can ensure that tidal flood management efforts remain relevant and responsive to changes in environmental conditions and community needs.

b. Cooperation and Coordination

Robust flood management cannot be carried out effectively without cooperation between various parties. The Bintan Regency Government is collaborating with the provincial government and the Regional Disaster Management Agency (BPBD) to obtain technical and financial support. Apart from that, collaboration with the private sector and non-governmental organizations is also being established to optimize existing resources. Collaboration between the Bintan Regency Government and the provincial government is very crucial in managing tidal floods. The provincial government has a role as a liaison between the central government and district governments, so that good coordination between the two can ensure the effective flow of information and resources. The provincial government also plays a role in planning and implementing policies that support reducing the risk of tidal floods at the local level.

BPBD, as the national agency responsible for disaster management, provides significant technical and financial support. BPBD can provide assistance in the form of disaster preparedness training, provision of flood management equipment, as well as emergency financial assistance when a disaster occurs. Collaboration with BPBD ensures that tidal flood management efforts in Bintan Regency are in line with national standards and receive adequate support from the central government. Bintan BPBD must coordinate with the Provincial and National BPBD to obtain the latest data, technical assistance and logistics during tidal flood management. Kijang City in East Bintan, with 199 affected families, can benefit from this collaboration.

The private sector has an important role in providing the financial and technical resources needed for tidal flood management. Through corporate social responsibility (CSR) programs, companies can contribute in the form of funding, building flood prevention infrastructure, or providing needed equipment and technology. This collaboration not only benefits local governments, but also improves the company's positive image in the eyes of the public. Local companies can provide assistance in the form of funds, labor and equipment. They can also support community education and preparedness programs. Companies in industrial areas such as Teluk Lobam in Sri Kuala Lobam can play an active role in this effort.

Collaboration between various parties allows optimization of existing resources. Each party brings different skills, resources, and networks, so this collaboration produces greater synergy than individual efforts. Local governments can benefit from technical and financial expertise from BPBD and international institutions, as well as logistical and material support from the private sector and NGOs. In this way, the tidal flood management program can be carried out more effectively and efficiently. NGOs can provide assistance in the form of training, education, and emergency assistance. They can also help in conducting research and collecting data to develop tidal flood management strategies.

Effective cooperation and coordination are key in dealing with the impact of tidal floods in Bintan Regency. Local governments, the private sector, communities and non-governmental organizations must work together to develop and implement mitigation and emergency management strategies. Active participation from all parties, both in planning and implementation, will ensure that tidal flood management efforts run well and efficiently. The integration of technology and science-based approaches will also strengthen regional capacity in dealing with tidal flood disasters.

c. Ecosystem Based Approach

Ecosystem-based coastal management is a strategy that integrates the natural functions of coastal ecosystems to reduce the risk of tidal floods and increase resilience to natural disasters. This analysis reviews various important elements that contribute to the effectiveness of this approach in Bintan regency.

- Mangrove forests play a key role in reducing ocean wave energy and reducing the impact of tidal floods. Mangroves' strong roots hold sediment and strengthen shorelines, thereby reducing erosion and increasing coastal stability. The mangrove rehabilitation program carried out involves replanting and restoring damaged mangrove forests. Data shows that areas that have been rehabilitated with mangroves have experienced a significant reduction in the frequency and intensity of tidal floods. Mangroves function as a natural barrier to sea waves and wind and help reduce the impact of tidal floods. Mangrove restoration in coastal areas such as Tanjungban City (North Bintan) and Penaga (Bintan Bay) can reduce the number of affected families. The Bintan Regency Government can carry out a large-scale mangrove planting program, involving local communities and non-governmental organizations (NGOs) to increase awareness and participation.

- Coral reefs function as natural barriers that absorb wave energy before it reaches the coast. Coral reef restoration is carried out by transplanting corals and protecting coral areas from destructive activities. Bintan Regency shows that areas with healthy coral reefs are more resistant to tidal floods and experience less damage during high tide events. Coral reefs function as natural barriers that can reduce wave speed and energy, thereby reducing the risk of tidal floods. Rehabilitation of coral reefs in areas such as Numbing (Coastal Bintan) and Sasah Bay (Sri Kuala Lobam) can help protect coastlines. Coral reef rehabilitation programs involving local divers and fishing communities can increase the effectiveness and sustainability of these efforts.
- Wetlands act as natural water reservoirs that absorb excess water during high tides and heavy rains. Wetland restoration through realignment of water flow and protection from human activities has increased water storage capacity and reduced the risk of flooding in the surrounding area.

An ecosystem-based approach in mitigating tidal floods in Bintan Regency involves mangrove and coral reef restoration, watershed management, green infrastructure development, as well as community education and participation. These steps not only help reduce the direct impact of tidal floods but also increase environmental resilience and sustainability of coastal ecosystems. Collaboration between government, communities, NGOs and the private sector is very important to ensure the success of this strategy and increase regional resilience to tidal floods.

The use of environmentally friendly materials, the materials used in drainage construction are selected in such a way as to minimize negative impacts on the environment. For example, the use of porous concrete allows water percolation into the soil, reduces surface runoff, and helps recharge groundwater. Adaptive design: This drainage system is designed to adapt to local conditions, including climate change and sea level rise. The drainage structure is designed to be flexible and able to accommodate varying water volumes. Adaptive design allows drainage systems to respond to climate changes such as increased rainfall intensity or changing water flow patterns.

This helps maintain the function of the drainage system in reducing the risk of tidal floods. A drainage system designed with flexibility is able to accommodate varying water volumes, from light rainfall to very high rainfall intensity. This reduces the possibility of waterlogging in urban and rural areas. By reducing the risk of tidal flooding, adaptive drainage system design also contributes to environmental sustainability. This includes protecting freshwater ecosystems, reducing water pollution, and maintaining environmental quality.

CONCLUSION

The coastal areas of Bintan Regency have been significantly impacted by tidal flooding, with North Bintan, East Bintan, and Teluk Bintan districts experiencing the highest number of affected households. The data shows that Tanjunguban Kota in North Bintan is particularly vulnerable, necessitating urgent flood mitigation efforts. Similarly, Kijang Kota in East Bintan also requires immediate attention due to the high number of affected families. This extensive impact underscores the need for targeted and comprehensive flood management strategies to protect the most vulnerable communities and mitigate future risks.

The Bintan Regency government has implemented various strategies to manage and mitigate the impact of tidal flooding. These include strategic planning and policy development through the Regional Spatial Planning Plan (RTRW), which regulates land use and promotes sustainable development. Infrastructure development focuses on improving drainage systems and building flood-resistant structures, while community education and preparedness programs aim to enhance local resilience. The formation of disaster-resilient communities and

the integration of green infrastructure are crucial steps in fostering a proactive and informed response to tidal flooding.

Effective tidal flood management in Bintan Regency relies on continuous monitoring and evaluation, robust cooperation among government entities, private sector involvement, and ecosystem-based approaches. Utilizing modern technology such as GIS and automatic sensors, the local government can make data-driven decisions and improve policy effectiveness. Collaboration with various stakeholders, including BPBD, private companies, and NGOs, optimizes resource utilization and strengthens flood management efforts. The restoration of mangroves, coral reefs, and wetlands further enhances coastal resilience, emphasizing the importance of preserving natural ecosystems as a defense against tidal floods. Through these integrated strategies, Bintan Regency can achieve long-term resilience and sustainability in the face of tidal flooding challenges.

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