IMPACT OF HOLTEKAMP BRIDGE CONSTRUCTION ON DISASTER MITIGATION IN JAYAPURA'S COASTAL ZONE, PAPUA

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ABSTRACT

Coastal areas are increasingly under pressure from various activities and natural phenomena. The construction of the Holtekamp Bridge in Jayapura has made Holtekamp Beach increasingly attractive as a trade and service area. However, these activities also increase the risk of disasters and affect the community's preparedness to deal with disasters. This article is the result of a descriptive qualitative study showing that the construction of the bridge has influenced the level of disaster mitigation both structural and non-structural at Holtekamp Beach. The novelty of this research article is to explore disaster mitigation in a coastal area in which settlement and business areas grow simultaneously. However, the existing mitigation measures are still uneven between the coastal area and the commercial area at Holtekamp Beach. Therefore, Holtekamp Beach needs to enhance disaster mitigation measures that are responsive to the area as a commercial and service hub due to reducing the risk of disasters that may occur in the future.

Keywords: *Coastal Area, Construction Impact, Disaster Mitigation, Holtekamp Beach Area*

INTRODUCTION

Indonesia is known as one of the countries with a high level of disaster risk (Kurniawati, 2020). This is due to its geographical location at the meeting point of three major tectonic plates in the world, namely the Indo-Australian, Eurasian, and Pacific Plates, as well as the presence of more than 127 active volcanoes. Based on Law of the Republic of Indonesia Number 24 of 2007 concerning Disaster Management, a disaster is defined as an event that threatens and disrupts the lives and

livelihoods of the community caused by natural, non-natural, or human factors, resulting in material and non-material losses.

One of the areas in Indonesia that is prone to disasters is the coastal area. The coastal area, according to (Permatasari, 2021), is a transition zone between the sea and land that is very dynamic and vulnerable to the pressure of human activities and natural phenomena. This area is often used for various activities, such as settlements, industry, ports, agriculture, and tourism. High intensity of utilization (Hidayah and Suharyo, 2018), climate change (Hsiung *et al.*, 2024), and geographical conditions (Yulianto *et al.*, 2021) make coastal areas in Indonesia increasingly vulnerable to disaster threats, such as abrasion, tidal floods, extreme waves, and tsunamis. In conclusion, coastal regions are susceptible to change their form due to natural processes such as natural disasters or events as well as changes that brought about by human development (Prasetyo, 2025).

The construction of the Holtekamp Bridge in Jayapura City, Papua, began in 2015. The main objective is to speed up travel time from Jayapura City to Muara Tami and Skouw Districts, which are the border gates with Papua New Guinea. In addition, this development is also designed to encourage the development of the tourism sector in Hamadi Beach and Holtekamp Beach (Mukaromah, 2019). The presence of the Holtekamp Bridge has a positive impact in the form of increased accessibility, economic growth, and the development of the coastal area of Holtekamp Beach into a center of trade and services marked by the emergence of cafes, restaurants, and resorts as new tourist destinations that offer the beauty of Holtekamp Beach, Yos Sudarso Bay, and Youtefa Bay.

However, the development of this tourist destination has been accompanied by increasing disaster risks in coastal areas. According to the Papua Province Disaster Risk Assessment for 2023–2027 (Papua Province Regional Disaster Management Agency, 2023), Jayapura City, particularly its coastal zones has been classified as a high-risk area. To address these challenges, spatial planning grounded in disaster mitigation is essential, in line with Government Regulation No. 24 of 2007 (Government of the Republic of Indonesia, 2007). Such mitigation measures not only reduce disaster vulnerability but also enhance the safety and comfort of communities and visitors engaging in coastal activities.

Many studies have been conducted on coastal areas and infrastructure development. For example, Bilalramadhan discussed the effect of accessibility on land use around the Youtefa Bridge (Bilalramadhan, Wambrauw and Agnesari, 2024), while Hamuna et al., evaluated the geomorphological vulnerability index on the coast of Jayapura City (Hamuna, Sari and Alianto, 2018). The novelty of this study is how to identify the influence of the construction of the Holtekamp Bridge on disaster mitigation preparedness in the coastal area of Holtekamp Beach.

This study aims to analyze changes in land use, infrastructure development, and disaster mitigation at the research location. Theoretically, this study is expected to expand knowledge about the relationship between infrastructure development, especially bridges, and coastal area mitigation. Practically, the results of this study are expected to be input for the government in formulating policies and planning for sustainable coastal area-based mitigation.

THEORY / RESEARCH METHODS

Land use includes a cycle of human activities involving interaction, balance, and dynamics on land with certain environmental limitations. Increasing human activities, along with population growth, drive greater demand for land, thus triggering changes in land use. The main factors of these changes include the expansion of administrative boundaries, upgrading of city centers, expansion of infrastructure networks, and urgent needs for certain activities (Pratama, 2023).

Infrastructure development, which is oriented towards the needs of local communities, is a long-term process that supports economic growth and equitable development. Yin et al., (2020) in (Tampubolon, Utami and Sutaryono, 2022) emphasized that infrastructure development is a government priority in supporting economic growth. However, on the other hand, this development also has the potential to cause land conversion and changes in spatial structure (Mardiana and Habu, 2020). Grigg (1988) in (Indrosaptono and Setiyawan, 2021) states that the bridge serves as the primary supporting infrastructure for the community's daily social and economic activities. Therefore, infrastructure can be considered as the main driver of economic growth as well as a challenge for environmental management.

The coastal areas of Jayapura City face the risk of geological disasters such as earthquakes and tsunamis, as well as hydrometeorological hazards such as extreme waves, abrasion, and extreme weather (BPBD Kota Jayapura, 2015). Disaster mitigation in coastal areas is divided into two main approaches: structural mitigation and non-structural mitigation (Wijanarko, Tondobala and Siregar, 2022), as regulated in the Government Regulation of the Republic of Indonesia Number 64 of 2010 concerning Disaster Mitigation in Coastal Areas and Small Islands.

Structural mitigation involves physical development and application of technology to minimize the impact of disasters Zakky, 2018 in (Basuki, 2020). Several indicators of structural mitigation based on Government Regulation of the Republic of Indonesia Number 64 of 2010 Article 15 relevant to Jayapura City includes:

1. Early warning system: Using technology such as Ina-TEWS, sirens, radio, and social media to provide rapid information regarding potential disasters (Sidik *et al.*, 2023).
2. Health infrastructure: Provision of health centers, pharmaceutical installations, and hospitals as a means of physical rehabilitation (Kementrian Kesehatan Republik Indonesia, 2011).
3. Evacuation routes: Construction of signs, routes, and evacuation sites (Rachman and Suryo, 2015).
4. Coastal protection structures: Construction of revetments, breakwaters, groins, seawalls, and jetties (Retraubun, Telussa and Halawane, 2022).
5. Coastal ecosystem management: Implementation of coastal vegetation and rejuvenation of coastal areas (Suwarji, Muffaroh and Puspita Sari, 2024).

Non-structural mitigation focuses on policies, planning, and increasing community capacity Zakky, 2018 in (Basuki, 2020). Several main steps of non-structural mitigation based on Government Regulation of the Republic of Indonesia Number 64 of 2010 Article 16 and (Ramadhani, Miladan and Kusumastuti, 2023) include:

1. Preparation of norms, standards, and procedures for disaster mitigation.
2. Mapping of potential disaster risks and regional vulnerabilities.
3. Preparation of Environmental Impact Assessment to ensure the sustainability of activities.
4. Mitigation-based spatial planning, such as the implementation of Coastal Boundaries (BSP).
5. Community education through training, simulations, and workshops related to disaster risk reduction.

Bridges play an important role in supporting connectivity, accessibility, and equitable development. In addition, this infrastructure can accelerate the evacuation process and distribution of post-disaster aid (Silondae, Muthalib and Ernawati, 2016); (Wijayanto *et al.*, 2023). Based on this understanding, it can be understood that the construction of bridge infrastructure will have positive and negative impact. According to Rd Cristo (2008) in (Aprilistya, Azhari and Pramesti, 2023), the term "impact" refers to something that occurs dues to something that is done and can be either positive or negative.

The definition of positive impact according to (Aprilistya, Azhari and Pramesti, 2023) is one that can convince and influence towards a better direction. This means that the bridge construction has a positive impact on improving the mitigation or disaster management in coastal area. Furthermore, there are some of the positive impacts such as:

1. Economic growth: Bridges open access to resources that support the economic recovery of communities after disasters (Husein, Hidayat and Susilowati, 2019); (UNDP and International Recovery Platform, 2010).
2. Evacuation access: Facilitates the distribution of aid and evacuation to disaster-affected areas (Pribadi *et al.*, 2018).
3. Disaster resilience: Bridge design must consider hazard risks and infrastructure sustainability (UNDP and International Recovery Platform, 2010).

Aprilistya, Azhari and Pramesti (2023) stated that negative impact is the opposite impact of positive which is leading to deviant or less desirable behavior. This mean that the bridge construction can also leading to opposite effect that potentially causing harm especially in mitigation or disaster management I coastal area. There are negative impacts such as:

1. New disaster-prone areas: Increased activity and buildings can increase disaster risks (Su, Chen and Liao, 2021).
2. Environmental degradation: Construction waste and activities without proper management can damage ecosystems (Steven *et al.*, 2020).
3. Changes in seawater flow: Bridges can affect seawater dynamics, especially in straits or bays (Li *et al.*, 2014).

Land use changes due to infrastructure development, especially bridges, have positive and negative impacts on coastal area mitigation. This study will explore the impacts of infrastructure expansion on Holtlekamp Beach, including the Holtekamp Bridge, as well as the implementation of structural and non-structural mitigation in the area. Thus, the results of the study are expected to contribute to sustainable development planning in coastal areas.

Research Method

The research was conducted in the coastal area of Holtekamp Beach, Jayapura City, Papua Province, especially at Holtekamp Beach from June to August 2024. The location was chosen because it is prone to disasters due to the construction of the Holtekamp Bridge connecting Jayapura City with Muara Tami District, especially Skouw Village. The construction of this bridge infrastructure has resulted in a change in land function into a tourism area. Because the tourism area is developing at Holtekamp Beach, this new tourism area is prone to disasters `(Lasaiba, 2024), so it requires a disaster mitigation strategy to anticipate the impact of disasters that will minimize human disaster victims and material losses.

This research uses a qualitative descriptive research method (Creswell, 2014). Qualitative research method is a research method used to research natural object conditions, where the researcher is the key instrument. Data collection techniques are carried out by triangulation, data analysis is inductive, and the results of qualitative research emphasize meaning rather than generalization (Abdussamad, 2021).

The research process began with an interest in examining how the construction of the Holtekamp Bridge in Youtefa Bay has influenced the emergence of new disaster-prone areas along the coast. The improved accessibility provided by the bridge has accelerated the emergence of a trade and service hub in the surrounding area, contributing to growing spatial density and, consequently, heightened exposure to natural hazards. This phenomenon forms the central problem addressed in the study (Daeng, 2023). Accordingly, the research aims to investigate the disaster mitigation process associated with the spatial transformation resulting from the bridge-induced development of trade and service areas in Youtefa Bay. The research incorporates both primary and secondary data sources to assess spatial transformation patterns and evaluate existing mitigation strategies. The findings aim to obtain conclusions from the research results that have been carried out (1).

Data was collected through interviews with tourism actors and visitors to gather information related to disaster mitigation (Cresswell and Poth, 2018). Direct observation and documentation in the field were conducted to see land use in the coastal area of Holtekamp Beach and the disaster mitigation currently being carried out (Pamungkas *et al.*, 2023). The data obtained were linked to theories related to changes in land use, infrastructure development, coastal disaster mitigation, and the influence of bridges on mitigation in coastal areas. In qualitative research Johnson & Christensen (2004) in Haryoko, et.all., (2020) explain that the essence of observation means studying objects or behavioral phenomena in natural situations. This means that researchers observe and analyze objects in the places where the phenomena occur or take place.

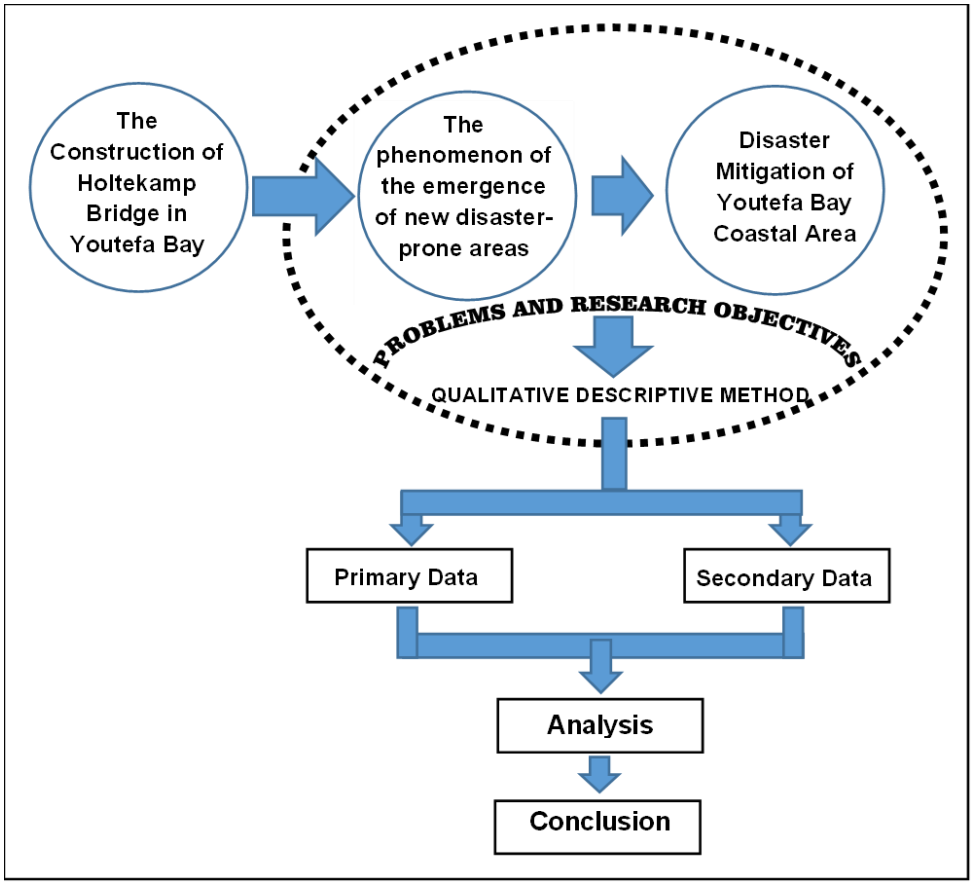

Figure 1. Diagram of Research Process

RESULTS AND DISCUSSION

The development of Jayapura City, especially in the coastal areas of Yos Sudarso Bay and Youtefa Bay, especially Holtekamp Beach (Figure 2) has undergone very significant changes. Basically, based on Jayapura City Regional Regulation Number 1 of 2014 concerning the 2013-2033 Regional Spatial Planning Plan, the Holtekamp Beach coastal area has complex spatial utilization. However, in the 2015 Jayapura City Disaster Risk Study, this area is still included in the disaster-prone area.

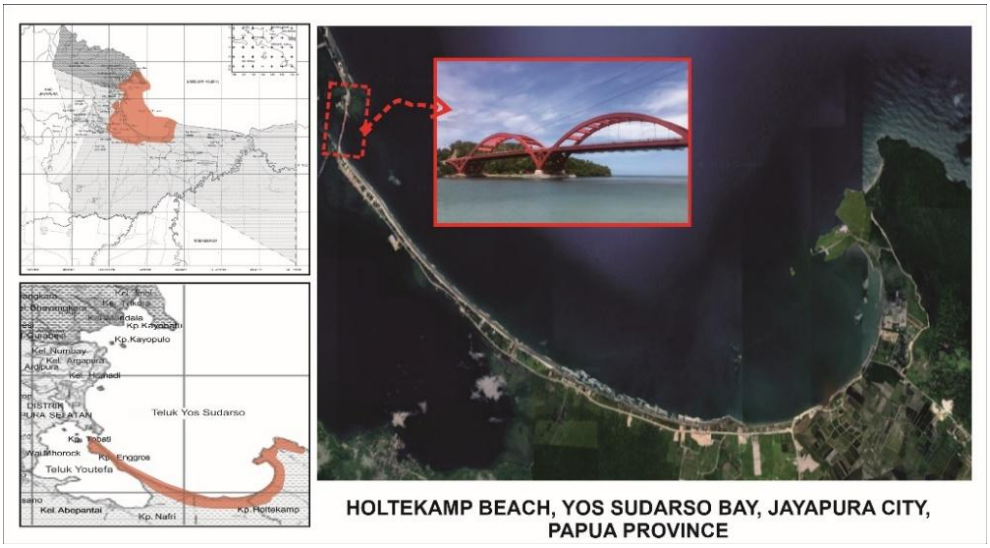

Figure 2. Location the Research in Papua Province

Darmiwati (2016) stated that almost all the coastal community are fishermen. This term also applies to the coastal community of Holtekamp Beach. The community relies on the natural environment that provides their livelihood and income. However, everything changed after the Holtekamp Bridge was built. Currently, the area is increasingly developing which is supported by Presidential Instruction 1 of 2021 concerning the Acceleration of Economic Development in the State Border Area in Aruk, Montaain, and Skouw, where the development of Holtekamp Beach, especially in the Holtekamp Village area, is directed to become an ecotourism and Beachfront zone. The coastal zone of the city always attracts tourists and supports local economies in order to increase the quality of the environment itself (Darmiwati, 2016). In 2014 (Figure 3), the Holtekamp Coastline was still a shady area with trees in the habitat. Then changes occurred when the Ring Road was built in 2012 and the Holtekamp Bridge in 2015. Both infrastructures were then inaugurated in 2019. So that in its development, the Holtekamp Bridge (Figure 2) also supports changes in the area that affect the sustainability of the area.

Land use changes adapt to human needs with the expansion of infrastructure networks (Pratama, 2023). The construction of the Holtekamp Bridge has resulted in the construction of the National Road on Holtekamp Beach, causing this area to experience rapid changes. Based on satellite images, the changes that have occurred are very visible when compared to 2014, 2020, and 2024 (Figure 3). The rampant land clearing has encouraged land conversion which has caused incompatibility in the use of space at several points in the area (Tampubolon, Utami and Sutaryono, 2022). This is shown in the Forest Area Map in the 2013-2033 Regional Spatial Plan in areas included in protected areas that have developed into trade and service areas. As a protected forest, development in the area is not permitted. Then the context of the area which is a disaster-prone area makes development in this area that is permitted is the

construction of semi-buildings. So that development that is not in accordance with these things is included in illegal development.

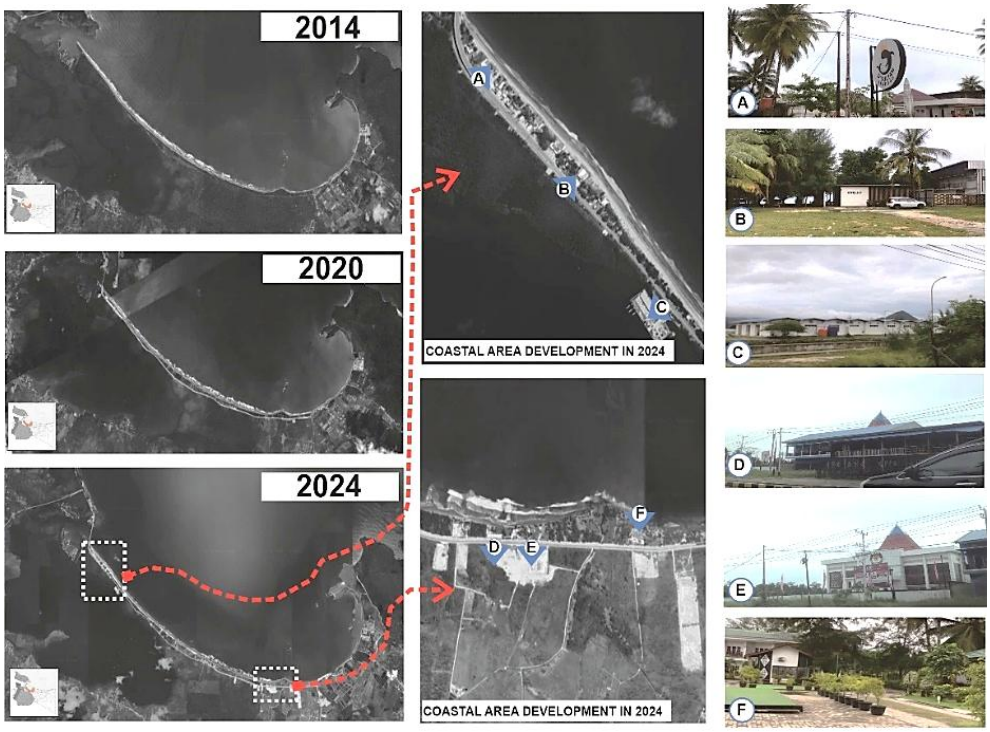

Figure 3. Changes in the Holtekamp Coastal Area, Jayapura City, Papua Province

The Existing Mitigation in Holtekamp Beach

The development of the area due to the Holtekamp Bridge has resulted in the need for structural and non-structural mitigation by the government. However, deficiencies and problems are still found at the research location. The existing mitigation is explained as follows:

Structural Mitigation

The Jayapura City Government has WRD-NG (Warning Receiver System New Generation) as an earthquake and tsunami information tool and one tsunami siren at the Papuan People's Assembly Office (Figure 4) (Sekretariat Balai Wilayah V BMKG Kota Jayapura, 2023). However, the siren radius does not yet cover all coastal areas in Jayapura City. The government plans to install additional sirens with a target completion in 2025 (Leloltery, 2024).

Figure 4. Reactivation of Jayapura City Tsunami Early Warning Siren
Source: BMKG Region V Jayapura, 2024

Health Facilities are one of the facilities needed in disaster-prone areas. However, in reality, the nearest health facilities are in Tobati Village, Enggros Village, and Holtekamp Village, as well as in Abepura Village and Hamadi Village. As a result, in the Holtekamp Coastal Area itself, there are no health facilities in the coastal area. Currently, there are 3 guard posts, namely 2 police posts and 1 RAPI post (Figure 5). However, rescue and evacuation facilities are still minimal, as indicated by only 1 evacuation sign at the Holtekamp Police Post (Figure 5). Through the DESTANA (Disaster Resilient Village) program, surrounding villages are prepared for rescue and evacuation. This creates an imbalance in the provision of rescue and evacuation facilities between surrounding villages and traders and service providers, especially for investors.

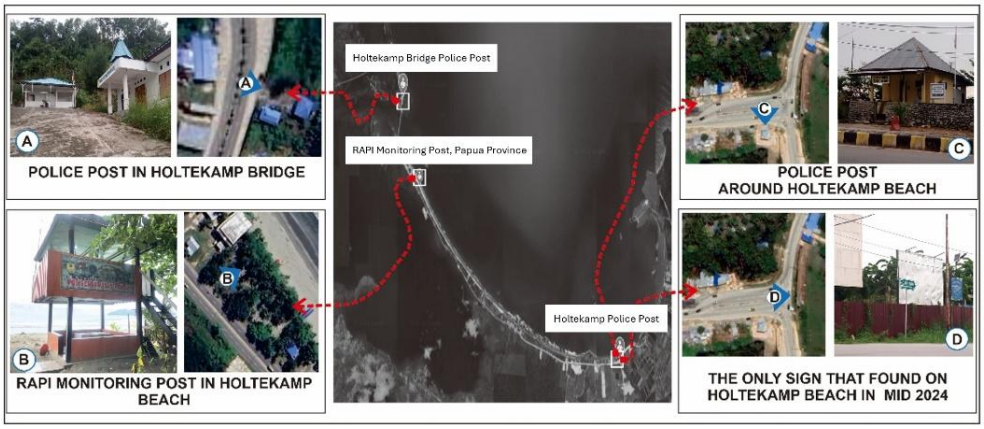

Figure 5. Location of Rescue Facilities and Evacuation Sign Points in the Holtekamp Coastal Area

The Coastal Protection Structure Wall at Holtekamp Beach has a breakwater and reclamation (Figure 6) which has not been fully effective in overcoming abrasion. This can be seen from several points in the area that are still affected by abrasion, one of which is the kiosks adjacent to the reclamation area. So, in this case, the government is temporarily building an emergency breakwater in the form of gabion wire.

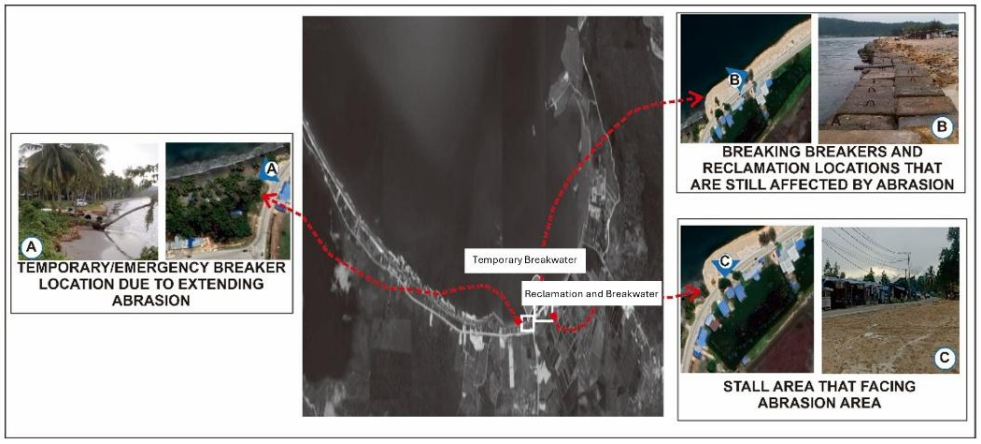

Figure 6. Location of Coastal Protection Structure in the Holtekamp Coastal Area

Ecosystem Management Mangrove reforestation and coastal rejuvenation have been carried out but are not enough to compensate for changes in the area. Abrasion and sea tides still have a negative impact on trade and service activities and the sustainability of the tourism area.

Non-Structural Mitigation

Studies related to spatial planning and documents related to disasters have been carried out. However, in the sustainability of the area, the study needs to be adjusted to the changes that occur in the area. In this case, the study in question is related to the Jayapura City Disaster Risk Assessment Document, the Jayapura City Spatial and Regional Plan, and other supporting documents.

At the village scale, education and counseling of the DESTANA program involving Tobati Village and Holtekamp Village for 7 months have been provided. Meanwhile, traders and service actors have only been given Water Rescue training, so it needs to be supplemented with mitigation simulations for traders and service actors as given to villages around the area.

Impact of Bridge Construction on Disaster Mitigation

The construction of the Holtekamp Bridge has a significant impact on the surrounding area, especially in disaster mitigation. The following is the influence or impact of the Holtekamp Bridge on disaster mitigation in the coastal area of Holtekamp Beach, Jayapura City, Papua Province. There are 2 types of impact: positive impact and negative impact.

Based on (Aprilistya, Azhari and Pramesti, 2023) explanation, positive impact tends to lead toward better direction. The following are some of the positive impacts of the Holtekamp bridge construction on disaster mitigation.

The Holtekamp Bridge supports regional development by connecting Jayapura City and Skouw Village which directly borders Papua New Guinea via the National Road. This infrastructure encourages economic growth in the trade, service and tourism sectors, as well as attracting investment in coastal areas (Figure 7). In addition, the bridge functions as a strategic route to support the post-disaster recovery process quickly and efficiently. As a result, the Holtekamp Bridge plays a role in supporting this process, especially in post-disaster economic recovery.

Figure 7. Trade and Service Points in the Holtekamp Coastal Area

While the Holtekamp Bridge plays the biggest roles in coastal area development and supports in post-disaster economic recovert, the government and coastal communities need to be cautious in utilizing the coastal area. Large-scale land use can lead to full damages of the sea-coastal environment because of overexploitation with low sustainable development (Zhai *et al.*, 2025). The Holtekamp Bridge plays an important role in accelerating evacuation accessibility. In addition, supporting infrastructure such as the Abepura-Hamadi ring road and the Hamadi-Skouw National Road also contribute significantly (Figure 8). This infrastructure connects strategic locations, including the nearest evacuation shelters in Abepura District, Hamadi District, and Muara Tami District.

The Holtekamp Bridge accelerates the distribution of rescue aid to areas that were previously difficult to reach due to the long distance. In addition, this bridge functions as an emergency route for pedestrians when a disaster occurs. However, its use as an evacuation route is more dominant in the coastal trade and service sectors, considering that several villages around the area, such as Tobati Village and Enggros Village, have special evacuation patterns. Tobati Village uses a church in a high area as an evacuation site, while Enggros Village accesses Abepura District via sea or to the Holtekamp Integrated Post (Figure 7).

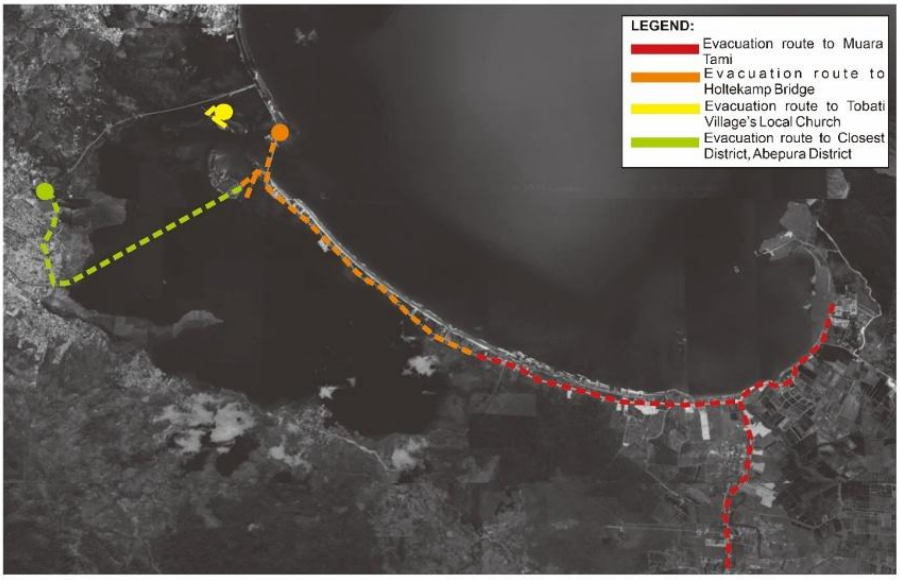

Figure 8. Temporary Evacuation Route and Location in the Holtekamp Coastal Area

From a technical perspective, the Holtekamp Bridge is designed for sustainable disaster mitigation. With Friction Pendulum technology, the bridge is able to divert earthquake energy into pendulum movements, making it resistant to earthquakes for up to 1,000 years (Firmansyah, 2018); (Prabowo, 2017). This design ensures structural resilience, reduces damage, and minimizes maintenance costs. In addition to physical infrastructure, this bridge also supports new disaster mitigation, such as accelerating the distribution of information and education to coastal communities. This increases the mitigation capacity of trade and service actors in the area, thereby reducing the impact of disasters effectively. Negative impact according to Aprilistya, Azhari and Pramesti (2023) refers to the opposite definition of positive impact which means that negative impact of Holtekamp bridge contruction on disaster mitigation leads to losses in social, economic, and coastal environmental aspects. The negative impacts obtained are as follows:

The development of the area around Holtekamp Bridge has created new disaster-prone areas due to changes in land use. The construction of cafes, restaurants, and lodging in disaster-prone areas attracts tourists, but the lack of mitigation results in high risks, including incidents of tourists being swept away by coastal currents (Figure 9).

Figure 9. Evacuation Process of Victims Swept Away by Waves on Holtekamp Beach
Source: Katharina, 2024

The construction of the Holtekamp Bridge has triggered environmental degradation due to changes in land use, including deforestation, accumulation of construction waste, and ecosystem disruption. In addition, based on (Waromi *et al.*, 2019), the constructed bridge is located in a disaster-prone area and being vulnerable to earthquake disaster even though it is designed to be earthquake resistant. Furthermore, this can lead to damage local habitats and threaten the livelihoods of communities and government that depend on the sea and forests. The bridge located in the Youtefa Bay Strait area also affects the dynamics of sea tides. The acceleration of the tidal rate has caused abrasion, especially on Ciberi Beach and Cape, which are located around the bridge (Figure 10).

Figure 10. Abrasion location in Ciberi Cape due to Strong Currents Passing the Holtekamp Bridge

CONCLUSIONS

This study identifies the impact of the construction of the Holtekamp Bridge on disaster mitigation in the coastal area of Holtekamp Beach, Jayapura City, Papua Province. The construction of the bridge triggered significant changes, including the conversion of the area from protected forest and nature tourism to a trade and service area. These changes increase the risk of disasters, especially in areas prone to geology and hydrometeorology. Although the government has implemented structural and non-structural mitigation efforts, the results of the analysis show that this mitigation is not optimal because it does not include trade and service actors. As a result, there is an imbalance in mitigation between community settlements and trade areas.

To ensure the sustainability of the region, mitigation strategies need to be updated. The government must expand the focus of mitigation, not only on settlements, but also on trade and service areas, which have the potential to have a greater risk of casualties when a disaster occurs. In addition, it is necessary to review mitigation policies, especially disaster risk assessments and regional spatial plans, so that they are in line with actual conditions in the region. This step will support more effective and adaptive disaster management in the future.

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