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Original Article

Societal Adaptation to Coastal Tidal Flooding in Sayung Subdistrict, Demak Regency

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ABSTRACT
A Tidal flooding (rob) along Pantura Road, Sayung District, Demak Regency has driven communities to develop various adaptation strategies for survival. Through descriptive qualitative approach with case study method, coastal community adaptation strategies were explored using observation, in-depth interviews, and documentation studies. Communities develop diverse adaptation strategies based on economic capacity, including: (1) physical adaptation such as raising house foundations, building multi-story houses, and using stilt house construction; (2) socio-economic adaptation through collective action in removing road barriers, utilizing new pond areas, and livelihood diversification; (3) public facility adaptation by raising cemetery areas and modifying school infrastructure. Government supports through pumping systems, water barrier installation, and sedimentation dredging. Tidal flooding reaches 40 cm height disrupting community activities, yet also opens new economic opportunities through fish cultivation. Findings demonstrate that community adaptation is dynamic and sustainable, combining individual strategies with local wisdom in addressing climate change impacts. The results contribute to understanding coastal community resilience and inform adaptive management policies for similar vulnerable areas facing sea-level rise and tidal flooding challenges.

KEYWORDS
Adaptation;
Tidal Flood;
Public.

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INTRODUCTION

Changes in weather that occur throughout the world provide real impacts on everyday life, especially for those who live in coastal areas. Indonesia, as an archipelagic country with thousands of islands and long coastlines, faces various challenges as a consequence of climate change (Widya Sari Utami, Petrus Subardjo, 2017). One of most frequent problems faced is tidal floods, which occurred when the sea water rises and floods mainland (Setiyono et al., 2023).

Tidal floods do not only caused by factors natural such as the ebb and flow of sea water, but also influenced by human activity man (Aulady et al., 2024). Excessive

groundwater extraction, environmentally neglectful urban development, and unregulated land-use changes collectively exacerbate the severity of the problem. Consequently, the frequency and intensity of tidal flooding have increased, exerting a direct impact on the livelihoods and well-being of local communities (Wirasatriya et al., 2006).

he regency, situated along the northern coast of Central Java, is among the regions most severely affected by tidal flooding (Sriyono et al., 2024). With an average elevation of only a few meters above sea level, the area is highly susceptible to inundation during high tides. Among its sub-districts, Sayung experiences the most significant impacts due to its proximity to the shoreline, making it the first area to be affected by rising sea levels (Rasmana Putra & Muh. Aris Marfai, 2021). The situation is further compounded by the Pantura Road, a major transportation corridor connecting key urban centers along the northern coast of Java, which traverses this vulnerable region (Aditya Listiyan Sutigno, 2015).

The Pantura Road serves as a vital artery for the region's economic activities. In recent years, the frequency of tidal flooding along the Sayung segment of the Pantura Road has markedly increased. Whereas such flooding previously occurred only during the rainy season, it now also takes place during the dry season, coinciding with high tides. This phenomenon indicates that tidal flooding in the area has become increasingly severe and warrants urgent and comprehensive attention (Kusuma et al., 2016).

The impacts of tidal flooding along the Pantura Road in Sayung are multifaceted and interrelated. In everyday life, local communities face considerable challenges in maintaining normal routines. Residential areas are frequently inundated, transportation routes become impassable, and clean water supplies are increasingly contaminated (Agustina et al., 2025). This situation places a significant burden on the local community, particularly because a large proportion of residents have limited financial resources, making it difficult for them to recover from the damage caused by tidal flooding (Kamal, 2024).

From an economic perspective, tidal flooding results in substantial losses. Damage to infrastructure and transportation networks imposes additional financial burdens on local communities. Moreover, traders and business owners operating along the road experience significant income reductions, as customer access becomes severely restricted during flooding events (Bigandata et al., 2023). Impact to the environment also does not lost serious. Sea water entering to mainland No only flooding surface soil , but also seeps in to in land and pollute fresh water sources (Syafitri & Rochani, 2022).

Various methods have been developed by local communities to cope with different types of tidal flooding. Some are individual in nature, such as elevating houses to withstand inundation, while others involve collective efforts through community-based mutual cooperation. This diversity indicates that there is no single solution suitable for everyone; each family or community group develops strategies that best fit their specific conditions and capacities (Asrofi et al., 2017).

Community adaptation to tidal floods has been widely studied, particularly in rural areas. Findings generally highlight that strategies such as constructing embankments, adjusting housing patterns, and increasing risk awareness are effective in enhancing resilience. However, most of these studies have focused on village contexts and have not addressed the situation along the Pantura Road, which serves as a strategic and vital transportation corridor. This gap in knowledge is significant, as tidal flooding along the Pantura Road exhibits distinct patterns compared to previous years, with higher water levels and longer periods of inundation.

The main objective of this study is to analyze and document various forms of community adaptation to tidal flooding along the Pantura Road in Sayung District. The findings of this research are expected to provide valuable recommendations for policymakers and relevant stakeholders in designing more effective mitigation and adaptation programs.

METHOD

The study was conducted along the Pantura Road in Sayung District, Demak Regency, Central Java an area that frequently experiences high-intensity tidal flooding. A qualitative descriptive approach was adopted to explore the various adaptive strategies employed by local communities in responding to tidal flooding along the Pantura Road. This methodological choice was made due to its capacity to provide an in-depth and holistic understanding of complex social phenomena within real-world contexts. Such an approach allows the researcher to describe, analyze, and interpret the range of community-based adaptation strategies developed to confront the recurring threat of tidal inundation.

The research design employed was a descriptive case study, aimed at providing a detailed account of the various forms of adjustments made by the community both in terms of infrastructure modifications and changes in daily economic activities. The study was conducted along the Pantura Road in Sayung District, Demak Regency, Central Java, one of the coastal areas that frequently experiences high-intensity tidal flooding.

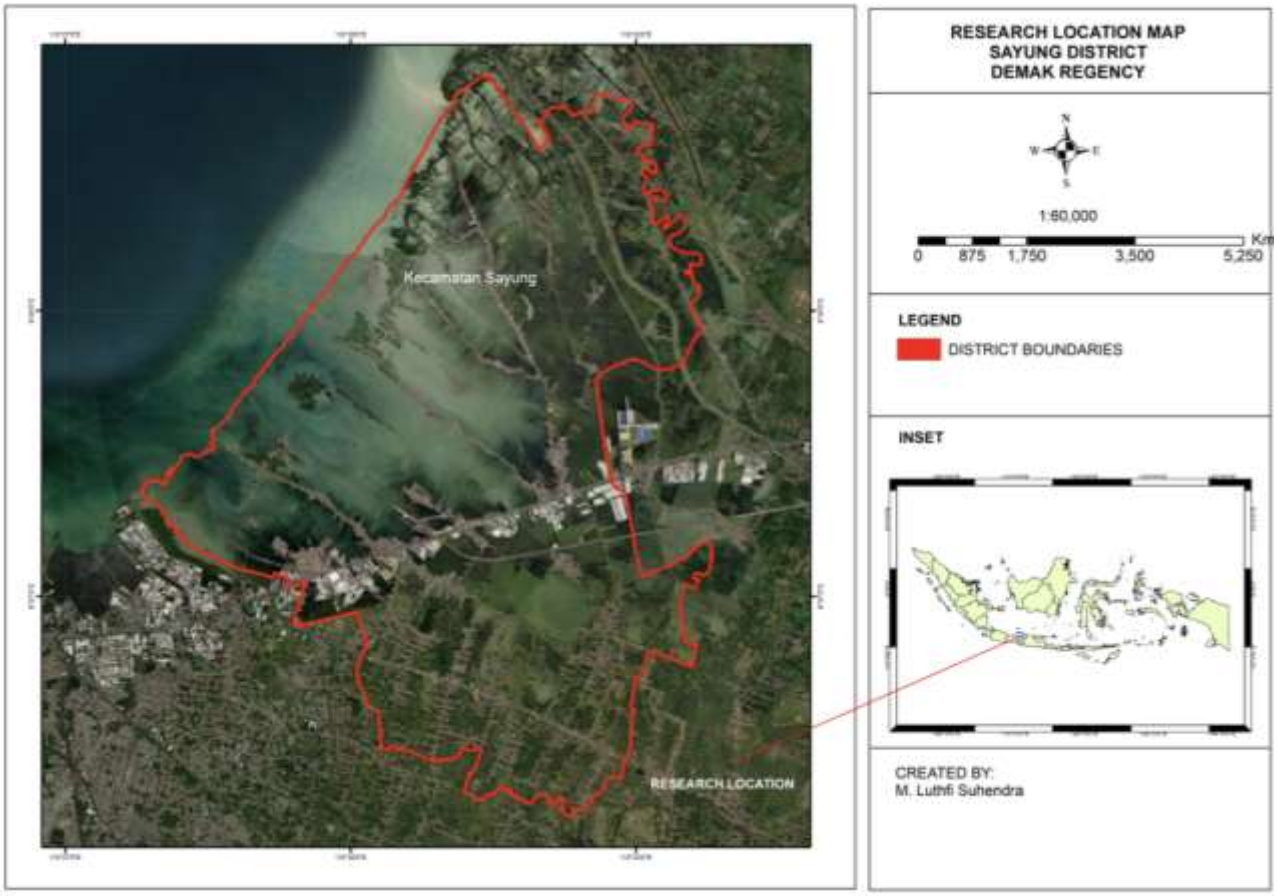

Figure 1. Research Location Map
Source: Research Results, 2025

Data were collected through three methods, namely observation, in-depth interviews, and document analysis, to enhance the reliability and validity of the findings. Observations were conducted to directly examine community adaptation practices in responding to tidal flooding, including infrastructural changes and social interactions occurring during such events. In-depth interviews were used to gather detailed information on the experiences, perceptions, and adaptive strategies of the community. A semi-structured interview technique with open-ended questions was employed to allow participants to share their experiences freely. Document analysis was carried out to collect supporting data that illustrated physical and environmental changes in the study area, thereby complementing and validating the primary data obtained.

The selection of informants was conducted using purposive sampling based on specific criteria, including having resided in the area for at least three years, having occupations affected by tidal flooding, possessing prior experience in developing adaptation strategies, and a willingness to participate in the research. The informants consisted of residents directly impacted by tidal flooding. The number of participants was determined using the principle of data saturation, whereby data collection was concluded once no new significant information emerged.

RESULTS AND DISCUSSION

Every year, recurring tidal floods strike Sayung Subdistrict in Demak Regency, particularly along the Pantura Highway. During the rainy season, water levels in this area

often rise sharply, creating significant environmental challenges (Khairullah & Azis Rifai, 2024). Based on data from the Demak Regency Information Service in June 2025, the North Coast Highway (Pantura) in Sayung experienced severe tidal inundation, which had widespread impacts on both the local community and road users. A water-level sensor installed in front of the Polytron factory recorded the lowest tide on June 2, 2025, at a height of 35 cm, and the highest tide on June 18, 2025, at a height of 55 cm.

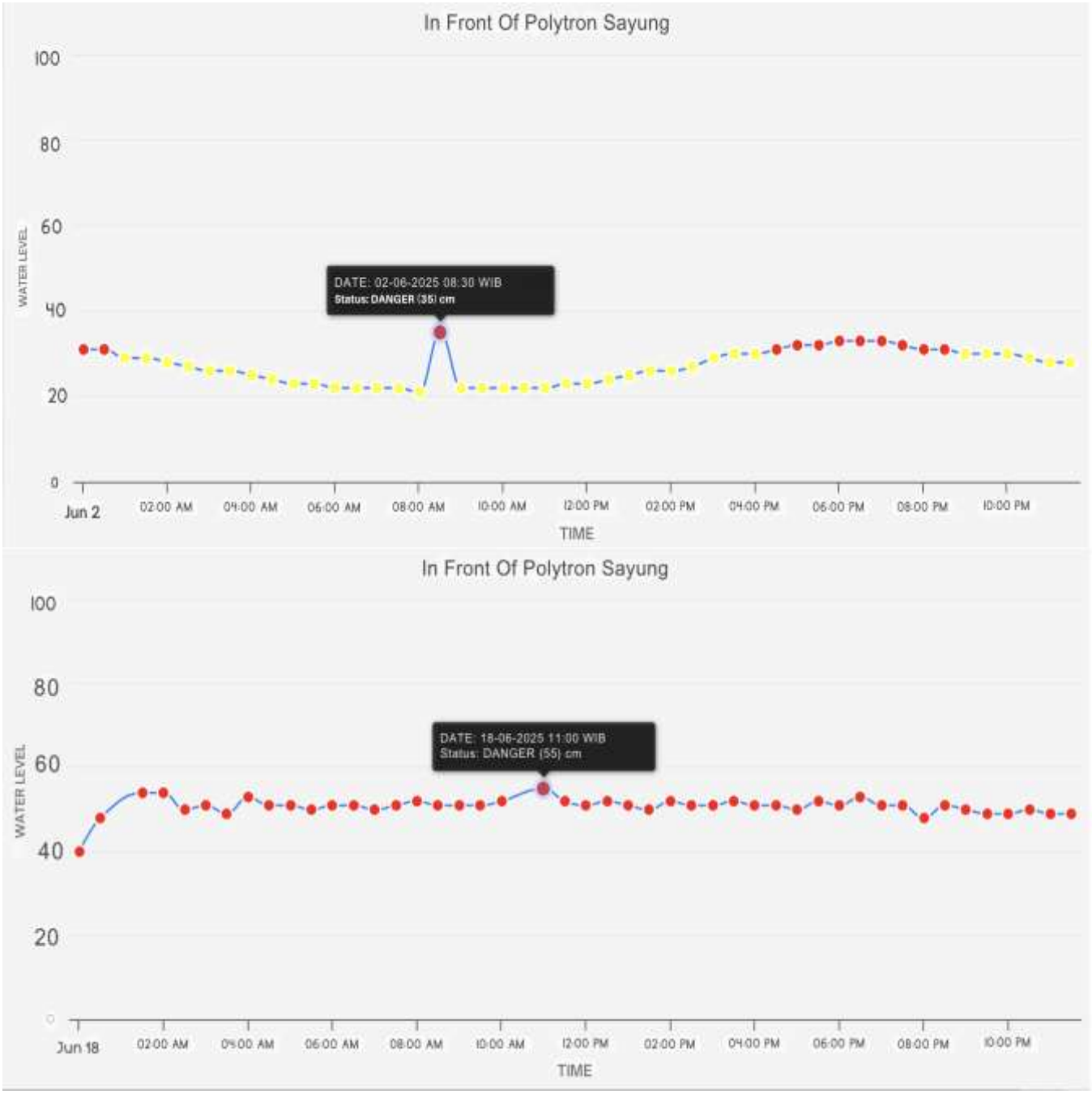

Figure 2. Difference in Water Levels on June 2, 2025 and June 18, 2025
Source: https://mipp.demakkab.go.id/deteksirob

Data obtained from the sensor indicate that the flooding pattern remains relatively stable, with water levels fluctuating according to rainfall intensity and tidal conditions. This suggests that the tidal phenomenon along the Pantura Road in Sayung is not a random occurrence, but rather a continuous and recurring cycle.

Informant selection was conducted using purposive sampling based on specific criteria, including having resided in the area for at least three years, having occupations affected by tidal flooding, possessing prior experience in developing adaptive strategies, and demonstrating willingness to participate in the research. The study participants consisted of residents directly affected by tidal flooding. The number of informants was determined using the principle of data saturation, whereby data collection ceased once no new significant information emerged.

Figure 3. Water Level Sensor in Front of Polytron
Source: Researcher Documentation, 2025

The water conditions around residential areas along the Pantura Road in Sayung, Demak, are still relatively suitable for daily use by local communities. Many residents rely on dug wells or drilled wells as their primary sources of water for bathing, washing, and cooking. However, several respondents reported that the water has become increasingly salty in recent years, which is believed to result from the intensifying intrusion of seawater into groundwater aquifers (Zevri, 2022). Despite this, in general, residents can still use groundwater for domestic purposes, provided it undergoes simple filtration or preliminary treatment processes (Musarofa et al., 2024).

The drainage channels along the Pantura Road in Sayung are generally open channels constructed from concrete or stone masonry, designed to discharge rainwater and tidal water into nearby rivers or water bodies (Annisyatun Nadhiroh et al., 2024). However, many of these channels have become narrowed due to sedimentation and the accumulation of waste, reducing their water retention capacity and slowing down flow rates (Setiyono et al., 2020). In addition, some drainage sections are unable to accommodate large volumes of water during heavy rainfall or high tides, resulting in waterlogging along roads and in nearby residential areas.

Flooding on the North Coast Highway in Sayung Subdistrict, Demak Regency, has caused severe traffic congestion that disrupts community activities. Many residents are unable to reach their workplaces on time and often become trapped in prolonged traffic jams, significantly extending travel times. This situation not only affects adults but also children, as numerous students arrive late to school or are unable to attend due to impassable, flooded roads (Haloho & Purnaweni, 2020).

The Pantura Road serves as a major connector between cities; when it becomes inundated, many drivers are forced to seek alternative routes, which are often longer and more time-consuming. The road also functions as a crucial transportation corridor for goods and people (Krama, 2022). Every day, numerous heavy vehicles, including freight trucks, pass through this route. High water levels make driving extremely difficult, and some motorists are even forced to push their stalled vehicles through the floodwaters. Such incidents raise serious concerns about the safety and comfort of local residents (Rahadiati et al., 2022).

Small and medium enterprises (SMEs) operating around the Pantura Road are also adversely affected by tidal flooding. During inundation, many business owners experience a sharp decline in customers, as flooded roads discourage people from stopping to purchase goods or use services (Rahma Dewi, 2023). Consequently, business revenues drop significantly, forcing some enterprises to temporarily or permanently cease operations. Moreover, many business owners must spend additional funds to repair flood-related damage, such as elevating shop floors or reinforcing building structures. The combined effects of declining customer numbers and rising operational costs place many SMEs at serious risk of bankruptcy (Berina & Wijayanti, 2012).

As an adaptation strategy, the community has implemented various measures to protect their homes from recurring tidal floods, largely depending on each household's economic capacity (Ardiyanto & Saputra, 2024). Residents with stronger financial means tend to elevate the foundation of their houses according to the estimated height of the frequent tidal floods or construct

multi-story buildings to minimize potential damage (Putri et al., 2024). Meanwhile, those with limited economic resources often opt for simpler stilt houses made of wood. Some residents, however, are unable to implement either strategy due to severe financial constraints and can only rely on assistance from local and national government programs (Indahsari & Hidayatulloh, 2023).

Figure 4. Condition of Elevated and Non-Elevated Houses. Source: Researcher documentation

One of the schools located along the Pantura Road has also suffered damage due to tidal flooding, forcing temporary closure during high water periods. This situation has disrupted the teaching and learning process (Eka Sarveleni et al., 2023). Many students are unable to attend classes regularly, and some have been compelled to seek alternative educational facilities elsewhere.

Figure 5. Graves Affected by Tidal Flooding
Source: Researcher Documentation

Cemeteries are also among the areas affected by tidal flooding. Submerged graves often experience structural damage, which not only deteriorates the physical condition of the burial sites but also disturbs the sanctity and peace of the resting place. This issue has become a serious concern for the community, particularly for families with relatives buried in the affected areas. To address this problem, residents living along the Pantura Road have made collective efforts to elevate the land around the cemeteries each year. This process involves gathering soil and other materials to raise the ground level of the burial sites in an attempt to prevent further inundation.

Public activities are also severely disrupted due to the increasingly frequent and intense tidal floods, which cause prolonged traffic congestion along the North Coast Road in Sayung Subdistrict. Many residents complain about the loss of valuable time caused by these traffic jams, while others express concerns about vehicle damage especially to motorcycles due to prolonged exposure to floodwaters.

In response, the community has worked together to dismantle road barriers that previously obstructed the flow of traffic (Amin, 2024). By removing these barriers, residents have been able to create alternative routes that help minimize the need for detours and reduce the risk of vehicles becoming trapped in flooded areas, thus allowing their daily activities to continue more smoothly (Isrofi & Gunawan, 2025).

Figure 6. Educational facilities affected by tidal flooding.
Source: Researcher documentation.

The increasing number of land ponds around the Pantura Road in Sayung District, Demak Regency, has created new economic opportunities for the local

community. The recurring tidal floods have transformed several low-lying areas into newly formed ponds, which residents have begun utilizing for fish farming activities adapted to the prevailing environmental conditions. These ponds have become an important source of income for the community (Izzah, 2022). In addition, many residents also spend their leisure time fishing in these flooded areas. This activity not only provides an additional source of food but also serves as a recreational practice that strengthens social bonds among community members.

Figure 7. Road demolition carried out by residents.
Source: Researcher documentation.

Figure 8. Fishponds
Source: Researcher documentation

Figure 9. Pumping Flood Water
Source: Researcher Documentation, 2025

Figure 10. Dredging Sedimentation
Source : Researcher Documentation , 2025

As a preventive measure, the government has implemented a pumping system to remove the accumulated water resulting from tidal floods. Through this pumping mechanism, it is expected that the water pooling around the Pantura Road in Sayung District, Demak Regency, can be effectively reduced. The implementation of this system aims to minimize the disruptive impacts of tidal flooding on community

activities and to protect vital infrastructure (Mutiarawati & Sudarmo, 2021). In addition to pumping, the government has also installed water barriers as a structural measure to hold back tidal inflows onto the Pantura Road, thereby preventing direct damage to road infrastructure. Furthermore, dredging of sedimentation in drainage channels has been carried out to increase water flow capacity. This dredging process is intended to remove sediment deposits that obstruct water movement, allowing the drainage system to function optimally during flood events. Through these combined efforts in improving the drainage system, it is expected that surface water accumulation can be minimized and the overall risk of tidal flooding can be significantly reduced.

CONCLUSION

Tidal flooding along the Pantura Road in Sayung Subdistrict, Demak Regency, is a recurring phenomenon that occurs almost every year. The physical and environmental conditions indicate that this phenomenon is not a random event, but rather a stable pattern influenced by rainfall intensity and tidal conditions. The social and economic impacts caused by these tidal floods are highly significant and multidimensional. Socially, prolonged traffic congestion disrupts daily activities, delays students from attending school, and hinders vital intercity transportation crucial to the regional economy. Economically, small and medium enterprises experience a drastic decline in income due to reduced customer access, with many being forced to temporarily or permanently suspend operations. Additional repair costs further burden the financial condition of business owners, increasing the risk of bankruptcy among SMEs.

The community has developed various adaptation strategies according to their economic capacity. Residents with sufficient financial resources tend to elevate the foundation of their houses or construct multi-storey dwellings, while those with limited means rely on wooden stilt houses. Some residents, however, are only able to depend on government assistance due to economic constraints. Collective adaptation efforts have also emerged, such as community cooperation in dismantling road barriers to facilitate mobility, and the development of new economic sectors through fish farming in ponds formed by tidal inundation.

Government efforts to address tidal flooding have been initiated through several programs, including the installation of pumping systems to remove accumulated water, the construction of water barriers to hold back tidal inflows, and dredging of sedimentation in drainage channels to improve flow capacity. However, these interventions have not yet been able to address the root causes of the problem comprehensively and sustainably.

Managing tidal flooding along the Pantura Road in Sayung Subdistrict requires a well-planned and sustainable strategy. The initial steps should prioritize direct assistance to affected communities, followed by the development of more resilient infrastructure such as coastal embankments, improved drainage systems, gradual elevation of roads, and the revision of spatial planning policies that account for flood-prone zones.

Nevertheless, this study has several limitations. One of them is the lack of longitudinal data, which makes it difficult to observe behavioral changes in community adaptation over time. Moreover, the study may not fully capture the socio-cultural factors influencing adaptive decision-making, and the limited number of respondents restricts the generalizability of the findings.

To address these limitations, future research should involve longer data collection periods and a broader range of respondents from diverse backgrounds. It is also essential to integrate multiple disciplines such as social and technical sciences and to involve the community directly in the research process so that their lived experiences and perspectives are fully considered. Through this approach, future studies can provide a more comprehensive understanding and offer more effective solutions to the challenges faced by the Sayung community in coping with recurrent tidal flooding.

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