Tidal flooding and coastal adaptation responses in Pekalongan City

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Abstract. Over the past 10 years, the coastal region of Pekalongan City has experienced the phenomenon of tidal flooding and has almost submerged coastal areas almost daily. At present, tidal floods have submerged 51% of the total area of Pekalongan City with a maximum inundation height of 1.1 meters. As a result, there has been damage to the economic, social, and physical (infrastructure). Adaptation response from all parties involved is needed to reduce negative impacts. The writing of this manuscript aims to find out the phenomenon of tidal flooding and the government's adaptation response together with the community in the coastal area of Pekalongan City. Lots of research on this issue, but in this manuscript focus on structural and non-structural adaptation responses. Data collection techniques in the study of literature and documentation. The results of the study showed that the tidal flooding in the coastal area of Pekalongan City in addition to sea-level rise and topography, this condition was also exacerbated by the phenomenon of land subsidence which reached minus 30-50 cm. Non-structural adaptation response by establishing disaster response organizations and disaster prepared posts, while early warning systems and flood control infrastructure are forms of structural adaptation responses.

Keywords: Tidal flooding, Structural adaptation, Non-structural adaptation

1 Introduction

Pekalongan City is one of the cities in Central Java which is located on the Northside of Java Island. The city has 4 districts with 27 villages with a total area of 4525 hectares [1]. Judging from the topography of the region, Pekalongan City is in the form of lowlands with a height of land between 1 meter to 6 meters above sea level. The average land slope is between 0-5% which is included in a relatively flat area. Based on RAN API, Pekalongan City is included in a region vulnerable to climate change, one of which is tidal flooding with a total inundation area of 1,920 hectares [2]. Subdistricts in Pekalongan City which are

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frequently affected by tidal flooding and classified as very severe are North Pekalongan Districts [3, 4]

North Pekalongan district is included in the coastal area of Pekalongan City which is vulnerable to the phenomenon of tidal or tidal floods. Tidal floods have occurred nearly more than the last 10 years in North Pekalongan district. In 2000, tidal flooding caused inundation at several points in the coastal area but did not enter into residential areas and floods that occur are not permanent. Starting in 2008, tidal floods entered residential areas and there was a permanent inundation [5]. Tidal flooding in the coastal area of Pekalongan City is expected to continue to expand along with the influence of sea-level rise with an average height of 9-88 cm which is predicted until 2100 [6]. This can cause damage to infrastructure such as roads, buildings/houses, public facilities, drainage, loss of productive land area, etc. [3, 7]. Besides, tidal flooding can also worsen the social and economic conditions of the community.

The Intergovernmental Panel on Climate Change (IPCC) explains that areas that are vulnerable to climate change such as tidal flooding, good adaptation is needed by all parties involved so that it is expected to reduce the negative impacts that will occur. This climate change adaptation focuses on changing individuals or organizations or institutions to be able to adapt to the conditions that are being experienced [8]. Meanwhile, according to [9], adaptation is a response to changes in a system consisting of institutions, communities, and individuals to adjust to conditions that have the potential to cause damage. Adaptation response can be done by utilizing existing capabilities and opportunities. This allows one to make adjustments to protect the survival and livelihoods of the impacts of climate change.

This manuscript aims to find out how the tidal flood that occurred on the coast of Pekalongan City and its adaptation response. This writing focuses on structural and non-structural adaptation responses by the government in collaboration with the community in facing the danger of tidal or tidal floods.

2 Method

This manuscript uses data collection techniques in library studies and documentation. The use of various references and documentation such as journal books, articles, and other relevant reading material is the main object [10]. The type of data used is secondary data. The descriptive analysis method is used to provide clear, systematic, objective, and critical information and description regarding the phenomenon of tidal flooding following the adaptation response in the coastal area of Pekalongan City. Descriptive analysis is done by selecting, comparing, and combining various information contained in the references so that relevant conclusions can be found [10, 11].

3 Results and Discussion

3.1 Tidal flooding (Rob)

Tidal flood or commonly referred to as rob is a natural phenomenon where seawater enters land when the sea level is in high tide. Rob is related to the motion cycle of the moon. That is because the existence of the moon's gravitational force on the earth is very strong which results in the movement of seawater towards the land [12]. Rob not only occurs in coastal

areas but is also able to go to the central part of the mainland because seawater intrusion can go through rivers, drainage, and even underground water flow [4].

Tidal floods on the coast of Pekalongan City occur almost every day during high tides. The duration of inundation time varies between 2-4 hours [13]. Even for inundation heights of 25-50 cm, it requires 6-9 hours of receding time [13], [14]. Based on data and information from the Department of Maritime Affairs and Fisheries the highest tide of Pekalongan City reached 1.1 meters. This situation caused tidal floods to reach terrestrial areas up to 3-4.7 kilometers or 51% of the total area of Pekalongan City [13], [15].

In 2015 the worst rob in Pekalongan City occurred in the North Pekalongan District area with a height of 20-30 cm [16]. The flood submerged seven villages where the worst point is in the Bandengan and Customs villages. Similarly in 2016 according to a journal written by [17], eight villages were inundated by rob including Bandengan and Customs. Reporting from the website tirto.id, in 2017 tidal floods have again occurred in North Pekalongan Subdistrict, especially in the villages of Kandang Panjang, Panjang Wetan, Bandengan, Krapyak, Panjang Baru, Dukuh, Degayu, Keraton Keramat, and Padukuhan Kraton with an altitude reaching 50 cm. In 2018, rob occurred in seven Kelurahans with a height of 60 cm. As was the case with the previous year, the most severe rob in 2019 occurred in North Pekalongan district. There are six affected villages in a total of seven villages [18]. Rob also occurred in 2020, as reported by the official website of the DPMPTSP in Pekalongan City is the worst rob in history. Rob happened in all villages in North Pekalongan District. Inundation height reaches 1 m.

Tidal flooding in the coastal area of Pekalongan City occurs due to sea-level rise, land subsidence, and the topography of the area which is classified as very gentle [3], [7], [19], [20]. The phenomenon of land subsidence on the coast of Pekalongan City worsens the tidal flood conditions. Land subsidence due to excessive exploitation of groundwater that is used for various human activities such as agriculture, industry, and people's daily needs [3].

3.1.1 Topography of the coastal area

North Pekalongan district is a coastal area because it directly borders the Java Sea. Topographically, this area is in the form of lowlands and beaches with a height of 2.5 meters above sea level. The slope in the district of North Pekalongan is between 0-8% which can be categorized as very gentle sloping [19].

3.1.2 Sea level rise

The phenomenon of tidal or tidal flooding on the coast of Pekalongan City is inseparable by global climate change. During the day, the temperature in Pekalongan reaches 30oC. The average rainfall of 200 mm/year. This has an impact on the sea-level rise which causes tidal flooding. Especially in coastal areas directly adjacent to the ocean. The increase in the earth's temperature followed by the expansion of the mass of seawater causes the acceleration of sea-level rise due to the melting of ice in the polar regions [13]. Based on reports [6], it is predicted that the average height of sea-level rise in 2100 will increase to 18 cm to 59 cm. These conditions cause an increase in sea level with an average of about 0.44 cm/year. This is also confirmed by the results of research [13] which estimated the

height of tidal flood inundation in 2050 with an average rise of sea level of 6 mm, then it will produce a maximum inundation as high as 135 cm.

3.1.3 Land subsidence

In addition to the effect of global warming which results in sea level rise which affects the polar ice conditions and increased rainfall, Rob on the coast of Pekalongan City is also affected by land subsidence [16]. At present, land subsidence in the city of Pekalongan is becoming increasingly widespread so that many areas have become lower [20]. This causes the area to be inundated when rob arrives. Data released by Pappalongan City Bappeda in2018 on the official website stated that land subsidence in the coastal areas reached minus 30-50 cm below sea level.

This land subsidence is caused by the loss or reduction of underground water. Land subsidence also occurs due to natural compacting of young sediments in alluvial plains which is also accelerated by anthropogenic factors in the form of excessive and uncontrolled groundwater uptake. This groundwater exploitation is used for various agricultural, industrial, and community daily needs [2]. Many deep wells taking points used for industrial activities exacerbate the condition of land subsidence on the coast of Pekalongan City [5].

3.2 Adaptation response

Rob events that occur every year for the past ten years have caused great physical, social and economic losses [7], [20]. Rob caused the economic collapse of the community, especially in the District of North Pekalongan. The following is a structural and non-structural adaptation response made by the government and the coastal communities of Pekalongan City to reduce the impact of tidal or tidal flooding.

3.2.1 Disaster response organizations

The existence of disaster response organizations in community groups is very important in determining the amount of adaptation capacity in an area. It can support social actors in the community to proactively determine the right steps in disaster management. Based on field observations, KATANA is a community organization located at the Kelurahan level, one of which is in the Kandang Panjang Village, North Pekalongan District. The KATANA organization was formed voluntarily from the community to raise awareness in dealing with a tidal flood disaster that cannot be predicted with certainty. The existence of this community organization in addition to voluntary but still pay attention to regional autonomy. This organization has been officially formed through the decision of the long enclosure village head in 2019.

The existence of community organizations regarding disaster response will be established relationships between one individual to another individual. This collective action will help individuals in society to overcome disasters [6]. The role of government, institutions, management in disaster response is part of the regional adaptation capacity [8].

3.2.2 Disaster alert posts

The ability of the government in adaptation efforts to deal with tidal or tidal floods is carried out by establishing disaster alert posts specifically in the North Pekalongan area. This post was established by the Pekalongan City Regional Disaster Management Agency (BPBD) in several areas. The disaster alert post operates 24 hours. The existence of this post is a follow-up to the establishment of the holding post located in the BPBD. The liaison between the community, the village government, the sub-district, to the BPBD is the purpose of establishing this disaster preparedness post. Figure 1. is the result of field documentation regarding disaster alert posts located in the northern area of Pekalongan City.

Fig 1. Disaster alert post located in the northern area of Pekalongan City

3.2.3 Disaster early warning system

One of the determinants of adaptive capacity in disaster-prone areas is the adaptation response in technology [21]. An early warning system is a form of adaptation response in the field of technology that is useful to minimize the risk of damage and loss that will have an impact on the social, economic, and physical environment. An early warning system in the city of Pekalongan is carried out by installing CCTV at several points, especially in the northernmost area (coastal) which is directly adjacent to the sea. Based on research [22] the delivery of information on tidal flood early warning is done through social media WhatsApp or sms from the government and related agencies to RT / RW representatives. Furthermore, information is forwarded to the public through announcements from mosques or schools. The effort is considered still ineffective because the dissemination of this information cannot be accepted by society as a whole.

3.2.4 Tidal flood control infrastructure

The response of the government's adaptation in dealing with tidal floods, one of which is the development of flood control infrastructure. Pekalongan City has a flood control infrastructure in the form of sea embankments and giant pipes (Figure 2.).

Fig 2. Tidal flood control infrastructure e. (a) sea dikes; (b) giant pipes

A sea wall is a form of government mitigation effort that collaborates with the community in dealing with tidal floods. According to the results of the study [5], the manufacture of sea dike has a height of 3 meters with a length of 7.2 km. Besides that, the installation of pipes and giant pumps in several puddles was also done to help remove trapped water. This response is considered to be very effective for the community, especially those living in coastal areas. During the establishment of the sea dike, coastal areas rarely occur inundation with very significant height.

4 Conclusions

Tidal floods that occur on the coast of Pekalongan City occur due to rising sea levels, land subsidence, and the very sloping topography of the region. Land subsidence reaching minus 30-50 cm below sea level exacerbates tidal flooding in the coastal area of Pekalongan City. The adaptation response was undertaken by the government together with the community in the form of the formation of disaster response organizations, disaster prepared posts, early warning systems, and tidal flood control infrastructure.

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