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# STUDY PRONE TO FLOODING AND ROB (TIDAL FLOODING) DISASTERS ON THE COAST OF SEMARANG CITY, CENTRAL JAVA BASED ON AN ASSESSMENT OF ECOLOGICAL CONDITIONS

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## ABSTRACT

The coast of Semarang City, Central Java, Indonesia has ecological problems in the form of floods and rob (tidal disasters) that are certain to occur during the rainy season and transition season. In general, areas prone to flooding and tidal flooding are found in coastal areas with the main condition of flat topography and supported by other factors that cause the area to become prone to flooding and tidal flooding. The purpose of the study is to assess the level of risk of floods and rob disasters on the coast of Semarang City qualitatively based on the factors that cause floods and rob disasters. The methods used are qualitative ecological assessment, literature review, and field review. The results showed that factors such as topography, geology, climate, hydrology support floods and rob (tidal floods), and population factors with a density of more than 1000 people / km² are part of the index exposed to high floods and tidal disasters.

**Keywords:** Semarang City Coast, flood, rob, ecological conditions

## INTRODUCTION

Semarang City is the capital of Central Java Province, Indonesia as well as a center of large-scale activities: economy, trade, services, industry, population concentration. All regions of Indonesia based on the BNPB study (2015) each region is vulnerable to various disasters, ranging from erupting mountains, landslides, floods. Semarang City is one of the areas that cannot be separated from the threat of disaster. Ecologically, the coastal area of Semarang City has flood and rob problems that occur every rainy season and transition season. Another problem is that part of the city area located in coastal lowlands is above a soft layer of soil, exacerbating the problem of flooding and tidal flooding that routinely occurs throughout the year. The total population of Semarang City of 1,659,975 people with an area of 373.78 km$^2$ has an average density of 4441.05 people / km$^2$ is a problem in handling local ecological problems. In this case, the population becomes the subject as well as the object of the target of handling.

Based on the general definition of natural disaster management legislation, namely Law of the Republic of Indonesia Number 24 of 2007 concerning Disaster Management, and its derivatives, the following definitions are mentioned.

Disasters are events or series of events that threaten and disrupt the lives and livelihoods of the community caused, both by natural and / or non-natural factors and human factors resulting in human casualties, environmental damage, property losses, and psychological impacts

Disaster-prone is the geological, biological, hydrological, climatological, geographical, social, cultural, political, economic, and technological conditions or characteristics of a region for a certain period of time, which reduce the ability to prevent, dampen, achieve preparedness, and reduce the ability to respond to the adverse effects of certain hazards.

The assessment of the flood hazard index is determined by basic parameters as a measuring instrument. These parameters are different for each disaster. The parameters used for determining the flood hazard index are: flood-prone areas, slope slope, distance from rivers, rainfall.

Based on the Hyogo Framework for Action 2005-2015 adopted by the World Conference on Disaster Reduction (WCDR), five priorities are defined in the framework, including:: 1. Put disaster risk reduction as a national and regional priority whose implementation must be supported by strong institutions 2. Identify, assess and monitor disaster risks and implement early warning systems 3. Leverage knowledge, innovation and education to build self-safety awareness and disaster resilience at all levels of society, 4. Reduce the factors that cause disaster risk, 5. Strengthen disaster preparedness at all levels of society so that the response is more effective (UNISDR, 2005).

According to the Central Java Disaster Risk Assessment (Deputi Bidang Pencegahan dan Kesiapsiagaan BNPB, 2015) that Semarang City in terms of flood disaster has a high disaster index. The high disaster index value shows that Semarang City every year is certain to experience floods and tidal floods regularly with an impact on the community at large.

## RESEARCH OBJECTIVES

Assessing the level of risk of floods and tidal disasters on the coast of Semarang city qualitatively based on the factors that cause floods and tidal disasters

## LOCATION

The research location is the coast of Semarang City, Central Java Province, Indonesia in an area with coordinates 6°50' - 7°10' South Latitude and the line 109°35 - 110°50' East Longitude. The coast of Semarang is bordered to the north by the Java Sea.

## METHODOLOGY

Assessment of coastal ecological conditions of Semarang City based on literature review, news reportage, and field observations. Assessment of the ecological condition of an area is carried out qualitatively based on parameters: topography, climate, hydrology, geology, oceanography, and population conditions. The assessment is based on the area broadly and generally based on field reviews.

The assessment methods for identifying the type of threat based on the 2012 BNPB Head Regulation are:

1. Flood prone is determined based on the height of inundation (depth), namely low (< 0.76 m), medium (0.76 – 1.5 m), and high (> 1.5 m)
2. The population index is exposed based on population density figures, namely low (< 500 people/km²), medium (500 – 1000 people/km²), and high (> 1000 people/km²)

Assessment of ecological conditions is based on the main factors causing floods and tidal floods such as: topography, climate, hydrology, geology, oceanography, and population. The assessment is carried out qualitatively based on observations of the general condition of field conditions and supported by official data issued by the government and the results of previous research.

## RESULTS AND DISCUSSION

Semarang City with an area of 373.78 km² administratively consists of 16 village districts. Sub-districts that have coastal areas include West Semarang, North Semarang, and Genuk sub-districts. Based on Semarang City Regional Regulation No. 14 of 2011 in Article 73 and Article 75, coastal sub-districts that are prone to tidal disasters and prone to flooding include: Tugu, Semarang Barat, Semarang Utara, Gayamsari, and Genuk.

The area height data of each sub-district is shown in Table 1. Almost most of the northern part of Semarang City has a flat topography, so that every rainy season and tidal period it is certain that the area will flood. According to Bony (1999) the height of Semarang City from the coastline to land as far as 4 km has a height of 0-1 m. The calculation results of Setyowati & Suharini (2011) for the Semarang city area show 65.69 km² downstream, namely the coastal area has a flat topography.

Table 1. High area in coastal area of Semarang City

| District | area height (meters above sea level) | topography |
|---|---|---|
| Tugu | 1,00 | flat |
| Semarang Barat | 3,00 | flat |
| Semarang Utara | 1,00 | flat |
| Genuk | 2,00 | flat |
| Gayamsari | 3,50 | flat |

Source: BPS Kota Semarang (2023)

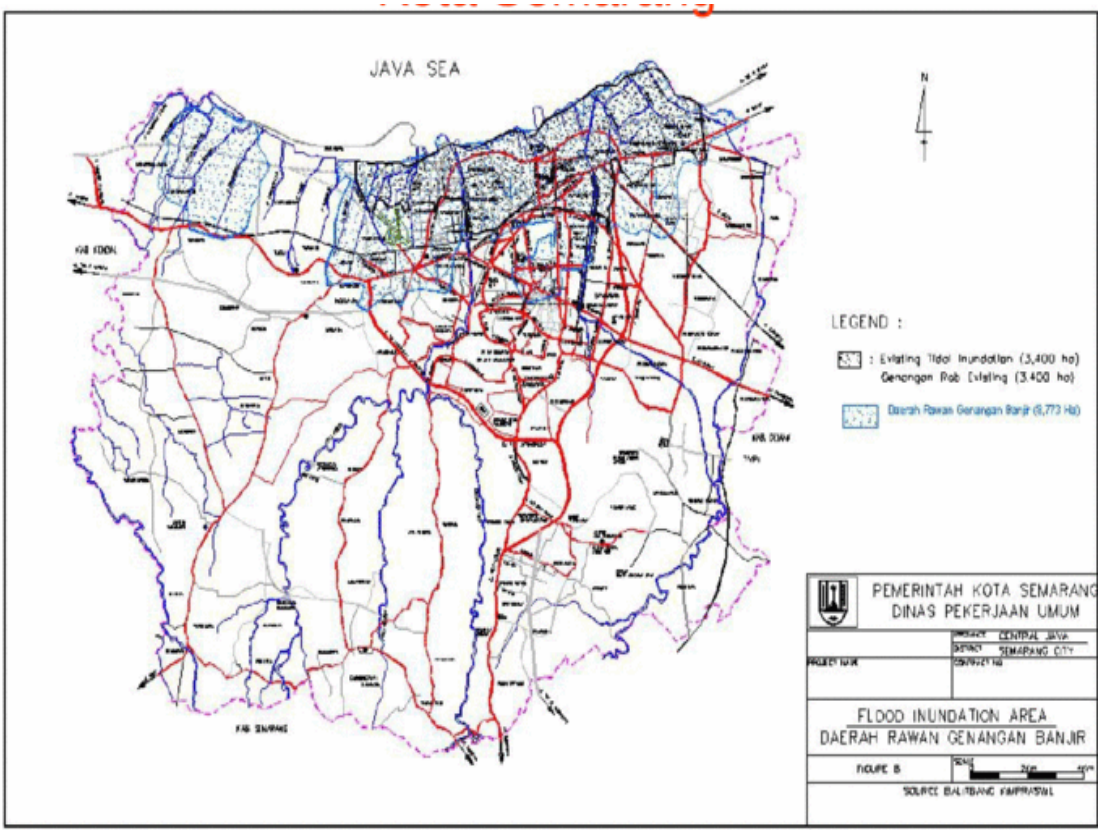


Figure 1. The coastal area of Semarang city affected by floods and rob (tidal floods) (Pemkot Semarang, 2014)

Rainfall conditions in Semarang are shown in Table 2. Heavy rainfall greater than 300 mm occurs in the following months: December, January, and February. Based on Table 2, for 2022, the peak of rain occurs in December (357 mm). According to BMKG criteria, rainfall is high if it reaches 300 – 500 mm. Based on the research of Rahmawati et al (2014) during the period 1990-2013, the average monthly rainfall in Semarang City has a monsoonal pattern characterized by unimodal rainfall (during the year has one peak rainy season). Peak rain usually occurs between December to February.

Table 2. Rainfall conditions in Semarang in 2022

| Month | Number of Precipitation (mm) | Number of Rainy Days (day) | Duration of sunshine (%) |
|---|---|---|---|
| January | 329,00 | 19,00 | 54,00 |
| February | 337,00 | 22,00 | 41,00 |
| March | 165,00 | 17,00 | 69,00 |
| April | 134,00 | 18,00 | 75,00 |
| May | 191,00 | 13,00 | 73,00 |
| June | 231,00 | 15,00 | 52,00 |
| July | 126,00 | 8,00 | 64,00 |
| August | 82,00 | 9,00 | 66,00 |
| September | 121,00 | 9,00 | 65,00 |
| October | 307,00 | 16,00 | 53,00 |
| November | 284,00 | 17,00 | 57,00 |
| December | 357,00 | 19,00 | 46,00 |

Source: BMKG (Badan Meteorologi Klimatologi dan Geofisika = Meteorology Climatology and Geophysics Council)

Hydrologically, Semarang city area is traversed by 23 rivers with a straight channel pattern. In addition, there are two flood control canals located on the west side of the city, namely the West Flood Canal and the East Flood Canal on the east side of the city. The main function of the rivers and canals is as flood control. Given that the coastal area of Semarang has decreased land, flood and tidal control is carried out by damming the river estuary and relying on pumping to reduce the impact of flooding that occurs on the coast.

Based on the drainage system, Semarang City is divided into three parts, namely the West Semarang drainage system with the main river, the Bringin River. The main feature is that the rivers are relatively small in size with headwaters in the hills. The river has water if it is the rainy season. Central Semarang drainage system with its main river, Semarang River, which is a continuation of the Garang river. East Semarang drainage system with its main rivers namely Babon River and East Flood Canal. Among the three drainage systems, the one that most often experiences flooding is the East Semarang drainage system. This is related to the condition of the coastal area in the form of tidal swamps.

The geological conditions in the coastal part of Semarang City mainly consist of sedimented clay layers. According to Dames (1955) the land on the coast of Semarang is in the form of tidal swamps with deposits in the form of sea clay. Wardoyo, et al. (2019) classify soil conditions in Semarang city as soft soil with land use mainly in the form of swamps. Most of

the building structures that stand in the soft soil area experience a process of decline in the building structure so that the building sinks into the soil layer. Field observations in the coastal area of Semarang City in 2024 conditions show that various building structures such as roads, bridges, houses, public facilities are almost all experiencing a process of decline.

The oceanographic factor on the coast of Semarang City that most influences the occurrence of rob is tide. Inundation of coastal land areas by rising sea water is accompanied by rising tide conditions. Based on tidal data for the 2018-2019 period, the lowest tidal range occurred in August (80 cm) and the highest in May (155 cm). According to Setiyono et al (2022) the highest tide position in May correlates with the incidence of rob. Rob is thought to have occurred due to the elevation of the Java Sea surface which is a combination of concentrating current flow in the southern part of the Java Sea and wind impulse coming from the north.

Table 3 shows data on area, population, and population density in sub-districts in coastal areas of Semarang City affected by floods and tidal floods. Data for Semarang City with a total area of 373.78 km² with a population in 2023 of 1,659,975 people obtained a population density of 4441.05 people / km² (BPS Kota Semarang, 2023).

Table 3. Area, population, and population density in coastal sub-districts in Semarang City in 2023

Sub-districts

| Sub-districts | Area area ($km^2$) | Population (people) | Population density people/$km^2$ |
|---|---|---|---|
| Tugu | 28,13 | 33.079 | 1176,14 |
| Semarang Barat | 21,68 | 146.915 | 6777,58 |
| Semarang Utara | 11,39 | 116.054 | 10186,71 |
| Genuk | 25,98 | 128.696 | 4953,84 |
| Gayamsari | 6,22 | 69.334 | 11147,11 |

Source: data processing based BPS Kota Semarang (2023)

Based on the criteria of Perka BNPB No. 02 of 2012, all coastal districts in the city of Semarang with a population density above 1000 people / km² have a population index exposed to floods and tidal floods including high class. The high class criterion can mean that floods and tidal disasters have a major impact on the large number of people exposed.

Table 4 shows the evaluation of ecological aspects of coastal areas of Semarang City related to vulnerability to floods and tidal floods. Evaluation of ecological conditions based on six (6) main criteria, namely topography, hydrology, meteorology, geology, oceanography, and population and land use. The assessment of ecological conditions on each ecological condition criterion is sourced from field surveys, map analysis, literature reviews, and official government sources containing the coastal ecological conditions of the City of Semarang.

Table 4. Evaluation of the role of ecological aspects in flood and rob disasters on the coast of Semarang City

| Ecological aspects | ecological condition | source/ reference |
|---|---|---|
| 1. Topography | | |
| a. Shape: (flat/oblique/hilly) | flat | Map/field survey |
| b. high place: (low/medium/high) | low | Map/field survey |
| c. coverage: (narrow/wide) | wide | Map |
| 2.Hydrology | | |
| a. Water catchment area: (small/spacious) | small | map |
| b. River capacity: (small/medium/wide) | small | Pemkot Semarang |
| c. Drainage network: (there/none) | there | map |
| 3.Geology | | |
| a. Rock properties: (soft/hard) | soft | Geology map |
| b. Type rock: (clay/silt/sand) | clay | book & article |
| c. Rock layer: (sediment/hard rock) | No role | book & article |
| 4.Meteorology (rainfall) | | |
| a. Intensity: (small/medium/high) | high | BMKG |
| b. Area coverage: (local/wide) | wide | Map |
| c. Continuity: (disconnected/connected) | connected | BMKG |
| 5.Oceanography: | | |
| a. Current: (weak/medium/strong) | No role | BMKG |
| b. Wave: (low/high) | No role | BMKG |
| c. Tide: (low/high) | low | BMKG |
| 6.Population and landuse: | | |
| a. Population density: (low/high) | No role | Pemkot Semarang |
| b. Settlements: (scattered/clustered) | scattered | Map |
| c. Builtland: (slighty/dense) | dense | Map |

source: data processing

Notes: BMKG - (Badan Meteorologi Klimatologi dan Geofisika/Meteorology, Climatology, and Geophysic Council), Pemkot Semarang (Pemerintah Kota Semarang/Goverment of City of Semarang)

In general, based on a descriptive assessment of 6 ecological aspects, it shows that coastal topographic conditions, namely flat coastal topography is the dominant factor or the most potential for flooding. Floods that occur on the coast of Semarang occur repeatedly every rainy season. Meteorologically, Semarang City has a unimoda type of rainfall, which is in one year there is one peak rainy season that occurs between December and February.

In the circumstances that cause flooding, topographic, hydrological, meteorological factors are closely related to cause flooding in the coastal part of Semarang City. Oceanographic factors, especially tides, play an important role in bringing up robs through the elevation of the Java Sea level which usually occurs in the April-June period.

Geological factors and land subsidence on the coast of Semarang are static factors but are factors increasing the increasing height of the rob. The geological factor in question is that the coast of Semarang City is on soft soil, so that various buildings that stand on it will decrease at a speed that varies from one place to another.

Population and land use factors are subject factors and casualty factors, considering that human factors play a role in occupying and managing the use of space in coastal areas. The population density in the coastal area of Semarang City of more than 1000 people / km² shows that the occurrence of floods and tidal floods in that location has an impact on the large number of people who will become victims of floods and tidal disasters.

## CONCLUSION

Based on a qualitative assessment of the ecological conditions (topography, geology, hydrology, and climate) of the coast of Semarang City, which includes five sub-districts, it shows that the area is prone to flooding, and oceanographic ecological conditions, especially tides, show that they are prone to rob. Flooding will occur every rainy season with one peak of rain occurring in the December-February period, while rob occurs in the transition season from the rainy season to the dry season in the May-June period. Population factors that are part of coastal areas are objects affected by floods and robs with a high-class disaster exposure index.

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