

Effect rainfall season on coastal flood in Semarang City

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Effect rainfall season on coastal flood in Semarang City, Central Java, Indonesia

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Abstract---Floods of rain always occur on the coast of Semarang City every time there is a change of season. The coastal city of Semarang has a flat topography with 13 rivers passing through, causing flood insecurity. The purpose of the study is reviewing rainfall patterns in Semarang City, and reviewing the relationship of rainfall with flood events in coastal parts of Semarang City. The materials used are secondary data (rainfall from BMKG, flood information from online media and newspapers) and field surveys (flood measurement and observation). Rainfall data processed with Excel, flood events (place, time, and height of puddles) are associated with the magnitude of rainfall. Analysis of the interrelationship of rainfall and flooding is associated with aspects of environmental conditions (topography, hydrology, geology). The results showed that during the period June 2018-June 2019 daily rainfall above 100 mm has caused flooding. Monthly rainfall above 100 mm occurs in December, January, February. The conclusion that the rainfall pattern in Semarang City is unimodal with the November-March rainy period and the peak occurs in January. Flat topographical conditions, a small network of rivers, and dense population are the deciding factors in the event of rain above 100 mm can cause longer calming.

Keywords---coastal, flood of rain, Semarang City.

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Introduction

Indonesia as an archipelago-shaped country located between the Asian continent and the Australian continent has a type of monsoon climate that is typical of the south and southeast Asian regions. Monsoon climate has the main characteristics of changing air pressure from Central Asia to Australia and vice versa every half year. The movement of air pressure is accompanied by a change in wind direction and a change of seasons. In Indonesia for one year there are two seasons, namely the rainy season and the dry season. During the change of season it is accompanied by a transition season. The effect of the change in the season, especially in the rainy season in various regions in Indonesia experiencing flooding due to rainfall. Semarang city is one of the cities that experience flooding every rainy season arrives.

Almost all parts of Indonesia every time the rainy season always causes floods and landslides. According to BNPB (2020) natural disasters in Indonesia caused by hydrometeorological factors are ranked number one. Severe flooding generally occurs in low-lying areas and valleys. Flooding is defined as an event or circumstance in which an area or land is submerged due to increased water volume (BNPB, 2020; Marfai, 2014). Kodoatie (2013) added that floods are of two kinds, namely floods occur in areas that usually do not occur in puddles, and floods due to overflow of water from rivers because the water discharge is greater than the capacity of the river.

In Indonesia, the rainy season generally occurs during the Period of November-April and the dry season occurs in the period of August-October, while the transition period occurs twice, namely from the rainy season to the dry season occurs in May-July, and the dry season to the rainy season in August-October. Each change of season will be followed by a change of wind direction, and then followed by a reverse change in sea currents in Indonesian waters.

In general, there are three types of rainfall in Indonesia, namely (1) the equator that covers the areas of Sumatra, Kalimantan, Sulawesi, Maluku, and Papua. (2) Monsoon type, covering Java, Bali, Nusa Tenggara, (3) reverse monsoon, covering a narrow area tucked away in parts of Sulawesi and Maluku. In equator type in one year has two peaks of rain, while in monsoon type has one peak of rain and anti-monsoon type has one peak of rain but opposite to monsoon type (Frampton & Uttridge, 1988; Prawirowardojo, 1996).

3 Semarang City is one of the big cities in Java located on the north coast of Java. As the provincial capital has a role as the center of government, the center of economic growth, industry, trade, and of course with dense residential areas. Semarang City has long faced environmental problems, namely flooding and rob problems in coastal areas that interfere with economic activities. The area along the north coast of Java, Indonesia, especially West and Central Java during the rainy season of the year is always hit by floods and continued in the transition season hit by rob that comes from the sea. According to BNPB (2016) that hydrometeorological factor (especially flood) ranks first in causing environmental

disasters in Indonesia. Semarang City is one of the areas with a high level of flood disaster insecurity.

Based on Indonesia's Disaster Risk Index in 2020, Semarang City has a risk index score of 115.52, which includes moderate risk (BNPB, 2020). The value is calculated based on the total amount of risk of various disasters, including flood risk. According to BNPB (2020) Semarang City has the potential for flood hazards at moderate to high levels by covering a risk area of 12,874 ha covering 15 sub-districts. The purpose of the study is (1) Reviewing rainfall patterns in Semarang City, and (2) Reviewing the relationship of rainfall with flood events in coastal parts of Semarang City.

Material and Method

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Location and time

The research location was conducted in Semarang City, Central Java, Indonesia with geography coordinates 6°50' - 7°10' S and 109°35' - 110°50' E (see Figure 1). The research took place during the period 2018-2019. The research is focused on the Genuk Subdistrict area.

Matter and method

The research method used is field observation and supported by the use of secondary data. Field observations include observations, measurements and interviews. Secondary data include flood inundation maps and drainase maps from Semarang City Government, yearly rainfall data from BMKG (The Meteorology, Climatology, and Geophysic Agency), flood history data from newspapers and online media.

Monthly rainfall data for a year is created into a table and a block chart. Field observation and interview data are matched with the inundation map published by Pemkot Semarang (the Local Government of Semarang City) (Figure 3).

The categories of rainfall and puddle height follow BMKG and BNPB respectively. Rainfall height criteria based on BMKG are: low (0 - 100 mm), medium (101-200 mm), high (201-300 mm), and very high (> 300 mm). Daily intensity criteria based on BMKG are: light (0.5 - 20 mm/day), medium (20 - 50 mm/day), dense (50 - 100 mm/day), very dense (100 - 150 mm/day), extreme (> 150 mm/day).

The criteria for height of inundation and population density based on Perka BNPB No. 2 of 2012. For height of inundation namely: low (<0.76 m), medium (0.76 - 1.5 m), and high (>1.5 m). for population density namely: low (< 500 population/km²), medium (500 - 1000 population/km²), and high (> 1000 population/km²).

Results and Discuss

Topography and hydrology

Generally area of Semarang City consists of three zonas, i.e. coastal plain, lowland, and hills. According to Muthohar (2017) that topography condition of

Semarang City consists of coastal plain (1 % of total area with altitude 0 – 0.75 m above sea level), lowland (33 % of total area with altitude 0.75 – 5 m), and hills (66 % of total area with altitude 5 – 348 m above sea level). Coastal area are widest in eastern part, and narrowest in western part. In addition to having flat topographic conditions, in coastal parts experience land decline at varying rates. Some research results (Bony, 1999; Gaffara, 2018; Prasetyo, et al, 2019; Yuwono et al, 2018) almost all stated that there was a decrease in land with a rate ranging from 0.5 cm / year to 20 cm / year with the fastest rate found in the eastern Semarang Area.

Based on the watershed division of Semarang City, it is divided into three watersheds, namely Bringin, Garang (with the Western Flood Canal and Semarang River) and Banjir Kanal Timur (the Eastern Flood Canal). Each watershed is named after the rivers in it. The river network of the three main watersheds forms 13 rivers that flow down the coast of Semarang City. Among the rivers that received the most attention because they often cause flooding are the Western Flood Canal and the Eastern Flood Canal (Pemkot Semarang, 2019).

Table 1 shows the condition of drainage subsystems in the eastern Semarang Area. Genuk Subdistrict area that is often hit by floods is only served by Kali Tenggang subsystem and Kali Sringin subsystem with total catchment area of 3,764.95 ha and river capacity of 40 m³ / second. The condition of the river system and its network is small to serve the coastal area with the flat topography.

Table 1
Area of East Semarang drainage subsystem area according to Semarang City
Drainage Master Plan (Pemkot Semarang, 2014)

No	Drainage subsystem capacity (m ³ /second)	Broad (ha)	Length of river (km)	River
1	BKT	3,704.80	6.7	100
2	Kali Tenggang	1,137.95	6.79	7
3	Kali Sringin	1,527.00	2.67	33
4	Kali Babon	12,715.28	10.8	6
5	Kali Pedurungan	1,076.88	3.5	-

Population

Based on BPS Kota Semarang (2019) the population of Semarang City in 2018 is 1,786,114. The area of Semarang city is 373.70 km², then the population density is 4,780 people / km². While the coastal sub-districts that include Mangkang, Tugu, West Semarang, North Semarang, Genuk have a population density above 1000 people /km². Based on the classification according to Perka BNPB (BNPB, 2012) the level of population density in coastal sub-districts that are prone to flooding includes high criteria.

Rainfall and flood

In general, the climate in Indonesia is monsoon type with four seasons, i.e. rainfall, dry, and two transitions. Wet season occurs during November-March with an intensity above 100 mm. The rainfall pattern in Semarang City is unimodal with the November-March rainy period and the peak occurs in January.

Based on Table 2 rainfall in Semarang begin in November and end in April with the peak occurring in January. During The months of December, January, February, March, and April rainfall is above 200 mm. According to the criteria BMKG belongs to the condition of the high category, and only January (above 300 mm) belongs to the very high category.

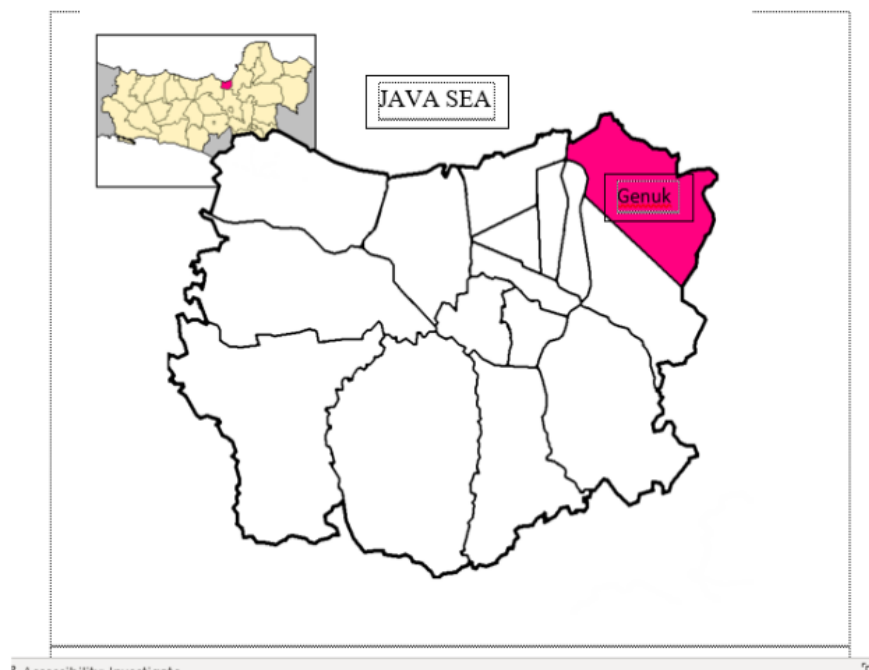


Figure 1. Location research is the Subdistrict of Genuk, as part of Semarang City, Central Java, Indonesia

Semarang City has a rainfall pattern during the period June 2018-June 2019 as shown in Figure 2. Rainfall above 100 mm starts in November to May with the peak occurring in January which is 370.6 mm (including very high criteria). Based on Rahmawati, et al (2014) research during the period 1990-2013 the average monthly rainfall in Semarang City has a monsoon pattern characterized by unimodal rainfall (for a year has one peak rainy season). The peak of the rainy season is generally most likely to occur in January, but may shift in the previous December or February thereafter.

There is a connection between the intensity of daily rain and flood events in the Subdistrict of Genuk area. Table 3 shows a list of flood events during the period

June 2018 - June 2019 with an observation focus on Jl Kaligawe (Kaligawe Road), Genuk Subdistrict. The first day of the 2018-2019 rainy season flood occurred on December 3, 2018. The last recorded flood event occurred on April 20, 2019. Almost throughout the rainy season the coastal area of Semarang City is certain to flood with the highest inundation conditions and long times of swimming in the Genuk Subdistrict area.

For in December 2018 monthly rainfall of 250 mm. On December 4, recorded daily rainfall of 105.7 mm (criteria very dense), it turned out that day in the Subdistrict of Genuk there had been flooding with a height of 20-45 cm that was monitored along Jl Kaligawe (Kaligawe Road) (Table 4). While in the southern part of Jl Kaligawe industrial areas and settlements in the Villages: Muktiharjo Lor, Gebangsari, and Genuksari the height of the puddle varies up to 50 cm.

Figure 3 shows the area of flood inundation in Semarang City with the largest puddle area found in coastal areas (Pemkot Semarang, 2014). Based on observations of the location of the occurrence of inundation is fixed from time to time. This is thought to be related to the topographic condition of the land surface of the location which is lower than the surrounding conditions. Every time there is heavy rain is ensured that the most severe locations occur inundation.

Discussion

Based on media sources on December 3, 2018 almost thoroughly in Semarang City there was heavy rain and flooding occurred everywhere, among others in Pemuda Road, Gajah Mada Road, Sriwijaya Road, Atmodirono Road, Kaligawe Road, etc. Based on daily rainfall data shows rainfall on December 3, 2018 was recorded at 32 mm and continued on December 4, 2018 was recorded at 105.7 mm. Rain continues continuously or for two days from December 3 and 4, 2018.

Based on the calculation of monthly rainfall during December 2018 is recorded as much as 254.5 mm. The rainfall condition can be classified as a wet month, which is above 200 mm. Based on the criteria of BMKG rainfall is high, which is a category between 200-300 mm. The peak of rain occurred in January 2019 of 370.6 mm which belongs to the very high category. Further in February 2019, rainfall decreased again almost the same as in December 2018, which was 256.7 mm

Table 2
Rainfall at BMKG station of Tanjungemas Port of Semarang during the period
June 2018-June 2019 (processed from BMKG 2018-2019)

Number according to BMKG	Time/month	Precipitation (mm)	Explanation
1	June 2018	73.1	low
2	July	0.4	low
3	August	0	low
4	September	4.1	low
5	October		no data
6	November	101.5	low

7590			
8			
7	December	254.5	high
8	January 2019	370.6	very high
9	February	256.7	high
10	Mart	211.8	high
11	April	211.3	high
12	May	101.8	medium
13	June	0	low

mm

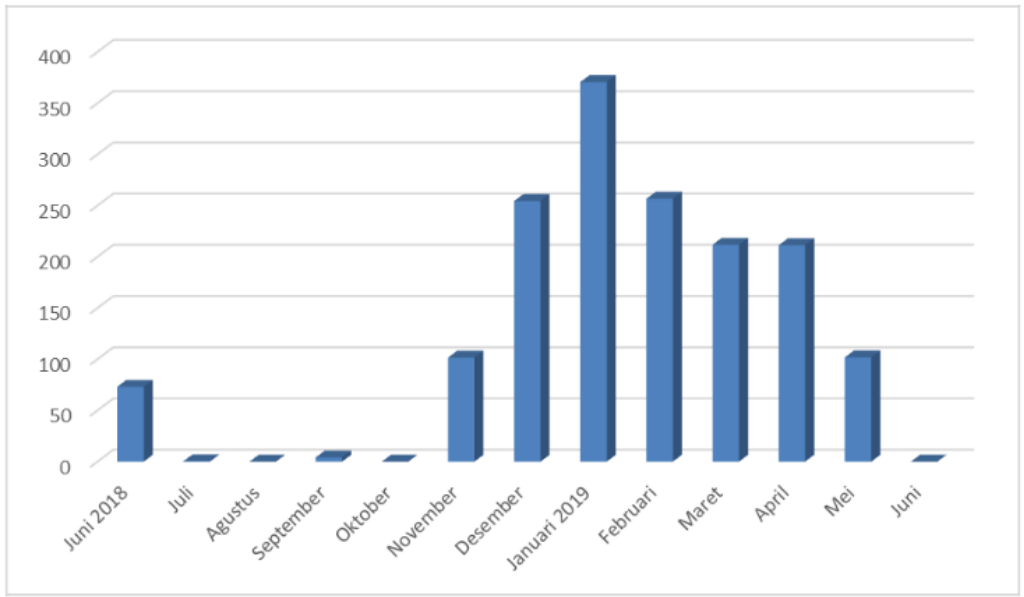


Figure 2. Rainfall in Semarang City during the period June 2018-June 2019 (Source: BMKG 2018-2019)

In April 2019, although the month has entered a transition period to the dry season, there is considerable rainfall for the size of April. Recorded rainfall in April 2019 was 211.3 mm, which included a wet month.

Based on the largest number of rainy days, the months of December 2018 and January 2019 were 25 and 26, or 5/6 months, respectively, rainy days. Based on the data means almost every day there is rain. Among the months during the rainy season period, December and January have a chance of flooding caused by rain. In fact, in both months there was flooding at the research site due to daily rain intensity above 100 mm. Aprianto, et al (2019) in his research on flood modeling in east Semarang City showed that the overflow of the Eastern Canal Flood caused the biggest flooding effect for Terboyo Kulon Village which reached an area of 112 ha and Tanjung Mas 107 ha. According to Findayani, et al (2019) based on GIS (Geographical Information System) and AHP (Analytical Hierarcy Process) analysis shows 37% of Semarang City area (141.4 km²) is prone to flooding.

Every year during the rainy season period, the coastal lowland area of Semarang City is always hit by floods. Residents living in the area include high criteria (>1000 people / km²) so that many floods cause major social and economic problems. Activity in the area will be disrupted considering Kaligawe Road in Genuk Subdistrict is the main connecting road between Semarang City and the cities to the east. Based on several studies due to frequent floods, local people adapt to how to dredge roads and elevate buildings, and make embankments. (Erlani & Nugrahandika, 2019; Putra & Handayani, 2013).

Since 2018-2019 began Flood and Rob Management Projects Semarang City with the main aim of reducing the impact of flooding and rob especially in the Subdistrict of Genuk. The work carried out include the manufacture of polder and pumping stations, as well as the manufacture of rob retaining embankments. Polder was created to hold floodwater from upstream. The collected water is then dumped with a pump into the sea.

This work was effective in reducing the risk of flooding and rob, it is known based on the results of interviews with residents in the Subdistrict of Genuk that since the operation of the flood control water pump system, since 2019 in the rainy season and the next transitional season there has been no flooding or rob. The spread of flooding and rob in Semarang City is found in coastal lowland areas (Figure 3). In the picture shown rob spread overlaps with the spread of flooding, especially in the eastern part of Semarang City. Area flood puddle covers 8,773 ha and rob puddle area covers 3,400 ha.

Table 3
Flood events in Genuk Subdistrict during the period 2018-2019

No	Date of incident	Location of the flood and description
1.	3-4 Desember 2018	The flood event is widespread in the Semarang City area, both at the lowland and the upland. Jl Kaligawe is flooded as high as 45 cm and varies in height in several locations.
2.	25 January, 2019	The rain was evenly distributed throughout Semarang City. Almost the entire Genuk District was flooded. Observations on Jl Muktiharjo Lor high puddle 20 Cm.
3.	12 Maret 2019	Floods are almost evenly distributed in the Semarang City area is no exception on Jl Kaligawe. Flood location: Jl (Jalan or street) Sriwijaya, Jl.Gajah, Jl Pemuda, Jl Sampangan, etc. The main cause is heavy rain throughout the day and evenly distributed.
4.	8 April 2019	Jl Kaligawe in front of Pasar Genuk (50-55 cm high). The water comes from the overflow of drainage channels to the south of Jl Kaligawe

5.	9 April 2019	Jl Kaligawe flood: front of Genuk Police- Genuk junction, Unissula front - Bugangan junction
6.	11-12 April 2019	Flooding occurred at several points on Jl Kaligawe: under the fly-over, front of Bugangan junction, front of RSI Sultan Agung, front of Polsek Genuk, between Sringin Lama River and Sringin Baru River
7.	20 April 2019	Flooding occurred at several point on Jl Kaligawe

Source: field observation

Table 4
Height of floodwaters along Jl Kaligawe on December 4, 2018

Coordinates	Location	Height of puddles (cm)
6°57'24,88"LS	110°27'05,23"BT	Under fly-over 45
6°57'23,10"LS	110°27'8,92"BT	Front of the Gate of Bugangan Industrial Estate 20
6°57'23,89"LS	110°27'29,66"BT	Front of RSI Sultan Agung 15
6°57'11,10"LS	110°28'34,28"BT	Around The Genuk Market 45

Source: field observation

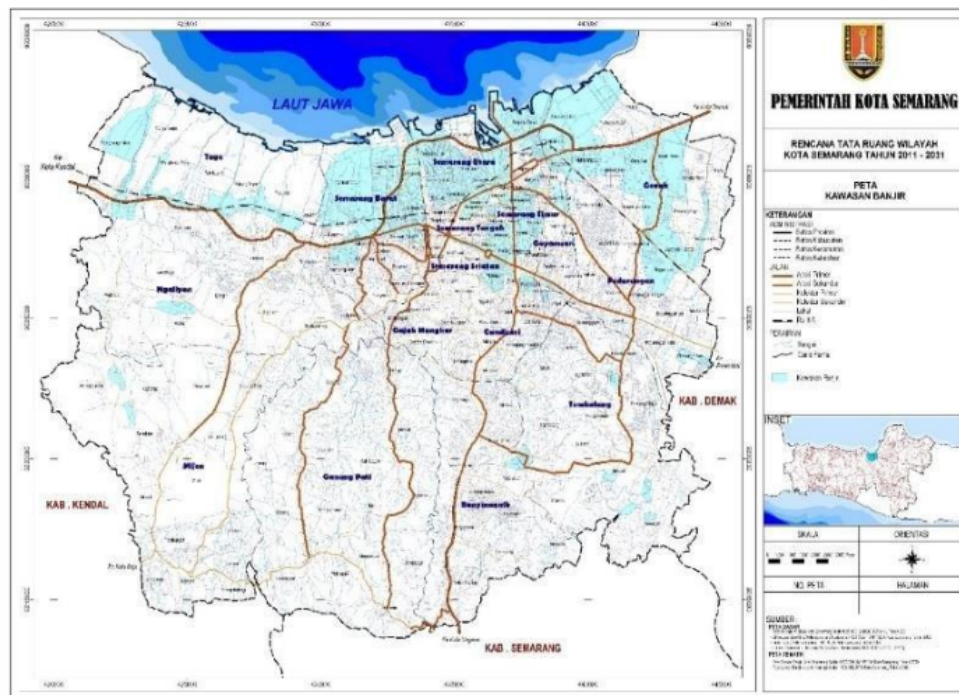


Figure 3. Map of Semarang City Flood Area (Pemkot Semarang, 2011)

Conclusion

In general, the climate in Indonesia is monsoon type. The rainfall pattern in Semarang City is unimodal with the November-March rainy period and the peak occurs in January. Coastal of Semarang City flooding from rainfall occurs during November-March with an intensity above 100 mm. During the period 2018-2019 rain with a high category above 200 mm occurred during December 2018 - April 2019 with a peak of rain in January 2019 with a figure of 370.6 mm. There is a close relationship between the amount of daily rainfall and the occurrence of floods in the Genuk Subdistrict Area. During December 2018 continuous rain for one week (December 3-8) caused the accumulation of rain that caused puddles during the period.

Puddles due to rain on Jl Kaligawe, Genuk Subdistrict range from 15 - 45 cm. The height of the puddle varies due to differences in the topography of the land surface. Relatively flat topographic conditions and inadequate river networks are thought to aggravate prolonged flooding.

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