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Handling Solution Tidal Flood in Kaligawe Area by Polder System Drainage

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***Abstract:** Kaligawe area is one of the main routes of North Java Coastal traffic and also the gateway of Semarang city from the east. Since more than 5 years this area proned by flooding due to a combination of land subsidence, increasing influence by tidal movement from sea the inability of free flow discharge of river water. In periods of flooding long traffic jams occur for more than 10 kilometers in length. The purpose of this research is to map the flood problem in Kaligawe area, identify the causes of flooding, analyze the technical handling solution and formulate the measures to prevent the flooding in this region. The research method is based on detailed field survey, measurement and observations of water levels, secondary data collection that consist of land subsidence's, rainfall intensities, tidal elevation. The data are analyzed qualitatively and quantitatively. Among the results of this study is to formulate measures to prevent the number and degree of flooding. These measures can be divided in short, medium term and long term stages. The short term measures consist of construct a temporary weir to regulate water discharge and pump installation including pump strategy. The medium term stage consists of making a polder system, the long term stage consists of spatial sustainability and institutional management of Operation and Maintenance of Polder system.*

***Keywords** : flood, kaligawe area, polder system, tide, traffic jams*

I. INTRODUCTION

Semarang City has a strategic location as the capital of Central Java Province, and developed as a trading and industrial city. Semarang city through the northern coastal transport route (Pantura) is very important in the national economy. Kaligawe area is, in 6° 56' 44.35" S 110° 29' 46.69" E, one of the main national routes and also the gateway of Semarang City from the east [1]. In the last five years, traffic on Kaligawe Street is often stacking totally due to flooding and inundation caused of sea level rise. Within the Kaligawe area many stakeholders/ functions suffer from flooding. The main functions within the Kaligawe area are industrial environments, offices, education, hospitals, and settlement of housing.

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Losses of the flooding are becoming more serious and increasing over time, major impacts of the flooding are traffic congestion, road damage, environmental and economic disruption of national scale. [2] In order to improve the condition and to anticipate to the impact of increasing flooding tidal inundation in Kaligawe area, it is necessary to review the existing drainage system. On short term time scale it will be necessary to undertake immediate action and formulate proper implementation of water management. This means it is needed to get the an overview of proper information and concepts to handle the surplus of water that lead to flooding. Because the Balisage area is quite busy area besides the water management perspective of view other challenges such as infrastructural planning, institutional preparedness and systematic handling of inundation are needed to take away the amount of flooding and in turn to solve the associate traffic problems. Because of problems getting worse action (measures in terms of water management) must place as soon as possible. Funding and plan and proper implementation are important to a well-functioning of measures/ actions. [3]

This paper aims to mention and propose how to handle floods in (short term) of Kaligawe region with the following systematics: flood problem mapping, identify causes of floods, formulate technical handling solutions, and give alternative institutional handling.

II. MATERIAL AND METHODS

The The research method was based on direct field observation, data collection by field survey and measurement as well as some secondary data sources. The data are analyzed qualitatively and quantitatively. As an in-house researcher, conditions and problems can be continuously followed, this is a very important to support analysis and justification stages for the middle term and long term stage.

A. Road and Traffic Condition

In the normal condition, the value of Level of Service (LOS) in Kaligawe Street has been already low, i.e. C and D level. The Value of Service Level of the Road is based on the ratio of speed (V) and capacity (C). So the traffic conditions on Raya Kaligawe Street is often congestion, especially during pick hour times on daily. [4] In the flooding period, water inundation on the road reaches about 0.5 meters from Low Water Spring (LWS) in Kaligawe Street KM4 (Bus station cross), KM5 (Macon sub-village) and KM 6 (Front of Genk Police Office), so the condition of the road is seriously jammed. As an illustration the elevation of Kaligawe street is between +0.85 to + 1.5 m.

While the daily tide elevation is +1.10 m and the highest tide +1.35 m. So every day there is always floods and jams, especially in the afternoon and evening. Traffic congestion will incur losses to residents in the area, road users or non-users of the road directly. Losses can be classified economically, socially and psychologically. To overcome the traffic stagnation, vehicles are transferred through another ring road, Welter Monginsidi road, but some road conditions are still damaged. Here's a picture of the Kaligawe area.

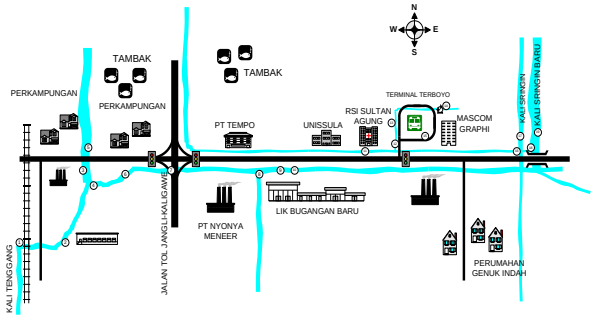


Fig. 1. Kaligawe Area, Semarang City [1]

B. Office, Industrial and Settlement Condition

There are several offices along of Kaligawe Street area such as PT Tempo, PT Telkom Indonesia, Jateng Bank, PT SIBA, Taxi Office, Nyonya Mener, Suara Merdeka that are suffering/ exposed to partial flooding. Besides these locations also Terboyo Bus station (main bus terminal of Semarang City) and Unissula campus, Sultan Agung Islamic Hospital, and Industrial area suffer from flooding and have a high economic value. The areas are also used to Industry activities such as LIK (small industry area), Industrial Area Terboyo, and Industrial Area Suara Merdeka. The lowest settlement area of this area is + 0.1 m from LWS. In periods of flooding these location are hardly accessible which lead automatically to traffic jams further away. In addition to the loss of material damage due to floods as well as productivity decreases because employees cannot go to their work or dismiss normal working schedules.

C. Drainage System

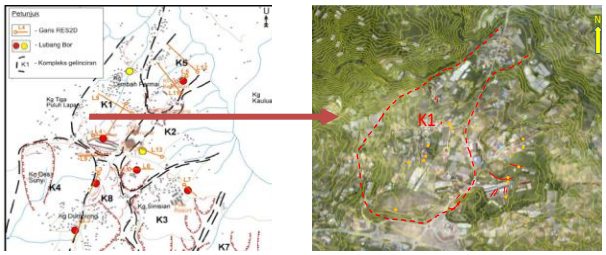
The drainage system in Kaligawe has two important flowing directions. South from the Kaligawe road water flows in west direction to the Tenggang River the catchment area is about 2400 ha. North from the Kaligawe road water flows in east direction to the Sringin River the catchment area is about 1500 Ha. [5]

1. Tenggang Drainage System

Tenggang drainage system has three directions of principal flow. The west side with downstream of Pacar River has area from east side of East Flood Canal River to Gajah Street. Then Central side of Area with downstream Channel along Railway has Jl. Supriadi, Tlogosari Housing and Muktiharjo Street. And Eastside with Downstream of Kaligawe Channel starting from Alas Tua, Housing of Genuk Indah and LIK (Small Industry Environment. This system passes through the kaligawe passage through two small bridges to the west and east crossing of Railway. The flow merges into the new Muara and also join to the East Flood Canal. At high tide water from seas enters freely upstream and causes tidal flooding. In rainy seasons and at times when rain is intense this situation leads to large puddles, it takes more than 1 week in being completely discharged. Sea level elevation is higher than the area, Polder system is required for handling. [6]

2. Sringin Drainage System

The drainage system Sringin has two main flows that discharge the surplus of water the New Sringin river and the old Sringin river. The new Sringin river flow comes from Banjardowo Village and the old Sringin river comes from Wolter Monginsidi street, Genuk market area and a long of Gebang Anom west. Road elevation and settlement area elevation under sea level. Therefore Sringin Drainage Network must also be used by Polder System drainage. That is to make dam to protect water flow from the sea. And then preparing water pump and providing adequate storage.



(a) (b)

Fig. 2. Comparison between the previous (a) and latest (b) boundary of K1 landslide system

III. RESULTS

A. Drainage System

Some aspects need to be reviewed to reveal the causes of flooding in Kaligawe Region. There are also technical aspects of non-technical aspects. The following are analyzed to explain the causes of flood technically.

1. Rainfall and Tidal

The highest daily rainfall recorded in BMKG (Board of Meteorology and Geophysical) ranged from 150 mm to 170 mm in 1994, 2006 and 2015. According to the criteria of rainfall classified more than 100 mm per day can be considered as heavy rainfall. In addition to the high rainfall the area (of Kaligawe) also receives a reasonable amount of discharge from the East Flood Canal. For the record in early 2017 there are three times the East Flood Canal overflowed into the Kaligawe area. In general, the bulk will generated maximum flood discharge in Kali Tenggang for 91,200 m3 / sec and Kali Sringin at 57 m3 / sec. The tide of sea water is determined by the low tide water condition i.e. +0,00 LWS (Low Water Spring). Seated +0.60m middle and high tide elevation about +1.25m from LWS, as well as highest tide + 1.35 m LWS. Every day the average tide up to +1,10 m. With a settlement condition of at least +0.10 m LWS, then the main road +0.85 m. It can be concluded every day there are puddles due to the tide.

In residential areas other than through the drainage system there is also a flow through the seepage of the soil as a porous medium.[7] With a non-permanent flow pressure similar to a sinusoidal flow. [8]

2. Subsidence of Land

Based on previous research on land the city of Semarang has land subsidence. Land subsidence mainly occurs in the Port of Tanjung Emas area and the Kaligawe area. The amount of land subsidence for the area Port of Tanjung Emas area ranges from an average of 6.5 cm per year to 5 cm per year for the Kaligawe region. [9]

Due to the amount of land subsidence water puddles can occur while rainwater isn't drained enough into existing drainage system and puddles can grew longer. From that to anticipate the next 20 years need to increase the height of the building ranges from 1 m, especially the building directly opposite the sea that is the dam of the river and the embankment that crosses the pond. The building also needs to consider the effects of local erosion or scoring.

3. Reduced Water Space

Watershed of Kali Tenggang is experiencing a rapid development of land use. For the upstream area of the river a lot of land in this watershed is a swamp, rice field and forest. Some village names actually show the origin of land in this watershed, for example Alas Tua (Old Forest), Sawah Besar (Big Rice Field), Tlogosari (Water Storage) and others. Today a lot of these former pature land grow in a more residential way leading to developments as industrial and office area and infrastructural area (way, roads and railway) one example is the existence of the big road toll road is the artery road of Sukarno Hatta and Jangli Kaligawe. For the downstream area, industrial area growth is Terboyo Industrial area, small industrial area of Genuk, Suara Merdeka Industrial Area, Campus of UNISSULA, the bus station and settlement of local housing. The development of the use of space is not accompanied by the improvement of drainage system. Likewise the water spaces have been reduced so much that the need for regulation to maintain and looking after the existing water spaces. [11]

4. Estuary Tenggang River and Sringin River

The Tenggang river estuary has two branches, the first being the one together with the East Flood Canal (KBT) and the new one directly to the sea. East Flood Canal is a river with a watershed of Ungaran, which is set in Pucang Gading dam, Semarang on the eastern part, then pumps coming from the drainage system around downtown Simpang Lima and Kali Banger. The KBT embankment is generally above the surrounding area, so it cannot receive water from the city by gravity. Because the estuary of Kali Tenggang is located in KBT, when rain stream from Kali Tenggang "back water" or have to queue the big stream of KBT. Sea water elevation during high tide is also higher with Kaligawe area so there is a tidal flood (Rob). According to visual observation, when the elevation of KBT and high sea area around Tenggang downstream. This condition also occurs in the estuary of Kali Sringin where the sea water flows into the river area. With the reality of sea level above Kaligawe area need to be used polder system.

5. Dimensions and Maintenance of Drainage

The amount of water flowing into Kali Tenggang cannot be accommodated based on its dimensions. At the downstream of Kali Tenggang or north of Kaligawe Highway, the condition is getting narrower also the right and left of the river grows urgent settlement towards the river. Maintenance by means of dredging is only possible for the location close to the road, but for the location where the settlement is coincident with the river leads (has leaded) to a more complex social problem because maintains of river profile (by performing dredging) is not possible. This condition causes the river to be shallower leading to higher water levels in periods of heavy rainfall and high river discharges.

For Sringin River the downstream dimension of the river ranging from Kaligawe road to river width is relatively stable the only the problem is the sedimentation (silt and clay) that need periodic maintenance. Due land subsidence and a stronger influence form tidal movement the last five years water tends to flow upside down from the sea to the river upstream. It is considered to be necessary to arrange a new polder not only preventing the influence from tides from sea but also a drainage system can discharge the surplus of rain and river water by existing or newly constructed drainage system.

1. Proposed Handling

To deal with some of the causes described above, technical and non-technical handling is also a clear institution. From the causes of the above is very difficult when handled simultaneously in the near future. To withstand flooding it is needed to come up with possible handling strategies that will make it possible to work gradually to solve problem. Proposed handling is presented from a perspective of short term run (1 to 5 years), medium term (5 – 10 years) and long term (10 – 20 year) time period.

2. Proposed Tenggang Sringin System Plan

Through planning of flood handling in Kaligawe area needs to be done immediately, although its physical implementation is implemented gradually. Tenggang river system can be divided into three sub-systems namely Pacar's sub-system, the original Grade Tenggang's sub-system and the Genuk's sub-system. Of those three sub-systems became one downstream. Since sea level is higher than Kaligawe and its surrounding areas, it is necessary to drain a polder system which is made of a dam that isolates seawater from the drainage system. While the water in the drainage system is discharged using a pump[12]. While Sringin river can be divided into two sub-systems namely the new Sringin sub-system and the old river sub-system. Both sub-systems become one in the estuary. Since sea water is higher than Kaligawe and Genuk areas, Sringin river drainage system also requires a polder system. Same with the principle described in Tenggang river system. Here is the proposed Sringin river system plan in figure 2.

Fig. 3. **Study Area (UKM, Bangi). Proposed Tenggang (TG) and Sringin (SR) Drainage System Plan**

Short Run

To stem the flow back from the sea to the land needs to be immediately created dam. As stated above the highest tidal sea elevation reached +1.40 m, while Kaligawe road elevation +0.85 m and even residents of elevation residents only +0.10 m. Here are temporary attempts at damming on the Sringin River.

Fig. 3. Temporary dam in the Old Sringin River

Fig. 4. **Study Area (UKM, Bangi).**

Simulation with temporary dam and pump with capacity of 1 m3 / sec, able to decrease water in Kaligawe area up to +0.30 m. And in the short term this system is operated to be able to maintain water elevation in Kaligawe Area up to + 0.70 m. This condition has a very significant effect on flooding in Kaligawe road and settlement environment and Industrial area.

In the near future there will also be a temporary dam for the Kali Tenggang system. In addition to damming the river that need to be observed is the leaks that occur in the area of the system because there are also some small drainage connected to the sea. In the implementation all the small drainage outlets are also closed and flowed to the main system from the upstream of the river dam.[13]

3. Medium Term

Based on more detailed observations of sea level elevation and measurement of land subsidence, in the medium term it is necessary to realize a permanent polder system with a permanent dam and a series of pumps and water reservoirs capable of anticipating flood discharge with a minimum 10 year period return. The strength and height of the dam need to be adjusted to the phenomenon of land subsidence. For example a land decline of 5 cm per year, for endurance for 20 years need to increase the height of 1 m which is applicable to river dam, tidal embankment and pump house.

Because the polder system requires a reservoir for rainwater it requires long storage which is the original river and also the addition of retention ponds. While the basic elevation of the river and the retension ponds is at least 1m, so it has adequate volume of storage according to pump simulation and water reservoir.

Whether it's in Sringin system or in Tenggang system it is recommended to do more research on the amount of volume of retention are within the two polder systems. [14] In addition to increasing the water storage, secondary pumps that reduce the flow of water to the main pump in the estuary. For example in the Tenggang system several alternative locations of pumps to dispose of water from the polder system to the East Flood Canal. For secondary pump Sringin system is needed to dispose of water from polder system to Babon River.

4. Long Term

In terms of river discharge channels of main drainage system is always in good condition it is needed to think of required and adequate operational maintenance (dredging, clogging from waste and mowing of vegetation within rivers and channels). In physical development to anticipate the impact of land subsidence, for example by determining the elevation of infrastructure. Then to reduce surface runoff discharge, it is necessary to reconsideration of land use and anticipate/ appropriate planning of existing and new drainage system(s). The land is still a swamp should be kept for water storage. The swamp and pool functioned as *"retarding basin"*.

When the system will be operational it is required to think of a sustainable way of pumping strategy so the amount of energy while pumping is needed will be minimized. For that need it is recommended to do research on a scenario's in which different pumping strategies are performed and more precise information is generated in the amount retention are (volume of retention ponds) within each polder is needed. After this prepared institution can be formulated so later handling in the operation and maintenance of this system is adequate to prevent flooding within the different polder systems.

5. Institutional Management

The handling of floods and congestion of Kaligawe requires a variety of institutions.

This means who is involved directly and indirectly in every process of activity. Institutions that play a role can be reviewed from the stages of its activities ranging from study, planning, socialization, implementation of construction and OP (Operational Maintenance). The institutions responsible for project implementation are usually followed by funding. This institution needs to be formulated to handle the road infrastructure and drainage and spatial planning. [15]

In the Kaligawe road infrastructure sector is a national road, so the handling of study, planning and construction is usually by APBN (National Budget) projects, but maintenance for Semarang neighborhood road needs to be handled by city-level institutions. To reduce maintenance costs as they are always damaged during floods, consider the use of flood resistant structures such as Concrete structures. Understanding of the development plan that will be done is also needed by the community so it can anticipate to the environment itself.

The Kaligawe Area with Kali Sringin and Kali Tenggang River Basin are all within the same drainage area and belong to Semarang City so it can be done by Semarang City. However when considering the national flooding problem, then the problems are also associated with the East Flood Canal River and the (land subsidence) and retreat coast line, it is necessary that higher role of institutions both at the provincial and central levels should take action/ funding. In short-term implementations that require large-scale handling and financing, an Institution from the Center for Water Resources is required. Whereas the extension of the central institution that has authority is the River Region Central Agency (BBWS) Juwana Pemali, Dirjen Water Resources, Ministry of Public Works and Public Housing (PUPR). We can compare to Banger polder that had a Water Boars to manage Operation and maintenance.

Because the problem of drainage handling is also very closely with the social aspect, then the role of society is necessary from the planning stage, socialization, construction implementation until the later stages of Operation and Maintenance (OP). Besides technical planning one need to be formulate direct handling institutions, sources of funding and linkages between institutions that are responsible on different levels as well as communities and private parties that are within the polders. Community participation can be realized in institutions within the Tenggang River and Sringin Care Group or more intensive participation in the Tenggang Sringin Water Management Agency.

IV. CONCLUSIONS

Landslide Flooding and jamming conditions in Kaligawe Region cause transportation, economic activity, Industrial environment, settlement environment and education environment and health facilities, so it needs to be handled immediately. Some of the causes of flood in Kaligawe are land subsidence, reduced water spaces, Tenggang and Sringin river estuaries and diminishing river dimensions due to settlement and sedimentation of sediment which is transported by river discharge. The proposed handling solution can be divided into three stages: short term with temporary dam and pump system for Sringin times continued Grace period, for medium term by making permanent dam and new drainage system lay-out and main pump equipment as well as secondary pumps. For the long term it is necessary to maintain the sustainability of water spaces (storage, discharge in rivers). For this last part operational and maintenance institutions should be created so the reliability of the drainage network is guaranteed because maintains works (and costs) are the well-known and undertaken at the right time by the appropriate institutions.

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