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Review on Flood Prevention Remedies Conducted by Government of DKI Jakarta

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ABSTRACT

As many other cities in the world, DKI Jakarta faces serious problems in the flood. In rainy season, common flooding is caused by several factors as follows: lowland areas in the northern part of Jakarta below sea level, urbanization rate, irregular population density, slum neighborhood where scattered rubbish where quickly provoke the flood to stagnate and increase rather than receding. This flood is mainly caused by not only above factors but also land subsidence an average of 5-10 cm every year. This paper reviews the Jakarta government's plan for flood prevention. Positively, Jakarta government has done some good policies such as the development of flood retaining spaces, dredging activities for shallow water rivers, water pumps development and management team. On the contrary, the government has made evictions to the communities located around the river, causing humanitarian and political issues. It was founded that the government program does not give significant implications to the welfare of society. The program also does not provide solutions to overcome flood prevention in DKI Jakarta.

KEY WORDS: *Japanese's River Culture; Flood; Jakarta.*

NOMENCLATURE

WFC	West Flood Canal
EFC	East Flood Canal
DKI	Daerah Khusus Ibukota
RTH	Ruang Terbuka Hijau
KK	Kepala Keluarga
BMKG	Badan- Meteorologi-Klimatologi-Geofisika
JABODETABEK	Jakarta-Bogor-Depok-Tangerang-Bekasi
BPBD	Badan Penanggulangan Bencana Daerah

1.0 INTRODUCTION

The high level of urbanization in DKI Jakarta has caused complex problems such as unemployment, crime, economic equality, housing, floods, traffic congestion, poverty, slums, water supply and urban planning. In addition, DKI Jakarta also faces some infrastructure challenges for water regulation caused by 13 rivers like Ciliwung, Kalibaru, Pesanggrahan, and other rivers caused by its unique topography. DKI Jakarta has unique topography that most of the city over the sea, with some sinks 25 cm per year with an average of 5-10 cm as shown in Figure.1.1.

Coupled with heavy rain during the rainy season, floods become a perennial problem that occurs every year in the rainy season. The floods in DKI Jakarta are commonly caused by several factors as follows: lowland areas in the northern part of DKI Jakarta below sea level, high urbanization level, irregular urban planning and slum environments coupled with scattered waste where, thus rapidly triggering flooding stagnation and rising rather than receding. Flooding occurred on the northwest coast of Java, at the mouth of the Ciliwung River in Jakarta Bay. Floods have occurred recently in 1996, 2002, 2007 and 2013, 2014, 2017. During the rainy season, floods occur in DKI Jakarta due to the above factors causing rivers full of garbage, clogged waterways, river sedimentation the high, and the overflowing seawater. Mixing flood water with a pile of waste in a narrow residential area can spur disease, including skin infections and diarrhea, especially in children under 5 years of age.

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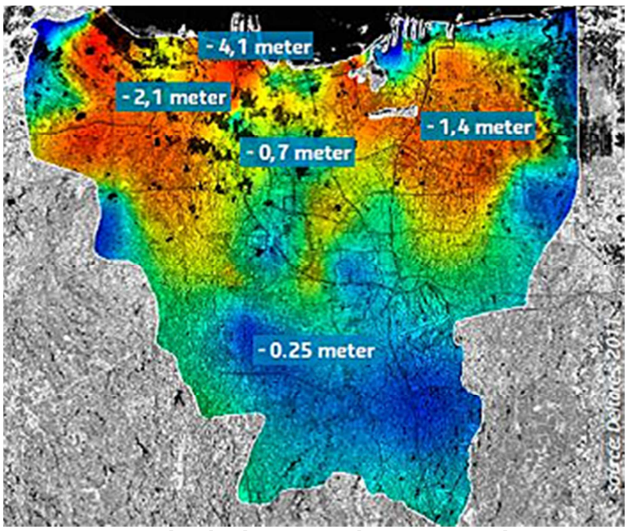

Figure.1.1: Land subsidence in Jakarta in period 1974-2010 [Indonesian & Dutch].

In order to overcome the complex problems as mentioned above, since 2015, the government of DKI Jakarta has made a program for resettling the population, especially the area adjacent to the river. This government program provides pros and cons at the general public level. This paper reviews the population evictions program and proposes a solution that may provide satisfaction to the government and the community.

3.0 DKI JAKARTA

3.1 History of Jakarta

Jakarta is the capital city of Indonesia as well as the largest city which is located on an estuary of the Ciliwung River. Short story, Jakarta was called Sunda Kelapa in the Kingdom of Sunda period then it was changed to be Jayakarta in 22 June 1527 during period of the Sultan Banten. In 4 March 1621 during Dutch colonial period (1619–1949), it was called as Batavia as shown in Figure.1.1, and then it was changed to be Jakarta Tokubetsu Shi in 8 August 1942 during the Japanese occupation. As Japan's defeat in World War II, Indonesian declared its independence on August 17, 1945 at Jalan Pegangsaan Timur No. 56 (Jalan Proklamasi), Jakarta Pusat and the position was immediately changed to the National Government of Jakarta or Provincial Government of DKI Jakarta.

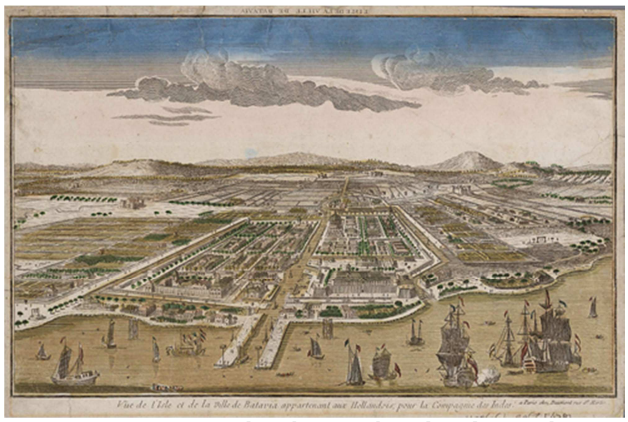

Figure.1.2: Batavia under the Dutch colonial period, 1780 [Wikipedia].

3.2 Geography of Jakarta

Jakarta lies in a low and flat alluvial plain, ranging from -2 to 50 metres with an average elevation of 8 metres above sea level with historically extensive swampy areas. 40% of Jakarta is below sea level particularly the northern areas, while the southern parts are comparatively hilly.

There is thirteen rivers flow through Jakarta. Firstly, river of Ciliwung divides the city into the western and eastern districts. The river of Ciliwung is across the city northwards towards the Java Sea which flows from the Puncak highlands to the south of the city. Other rivers include as follows: Kalibaru, Pesanggrahan, Cipinang, Angke River, Maja, Mookervart, Krukut, Buaran, West Tarum, Cakung, Petukangan, Sunter River and Grogol River. These rivers flow from the Puncak highlands to the south of the city, then across the city northwards towards the Jakarta Bay as shown in Figure.1.3

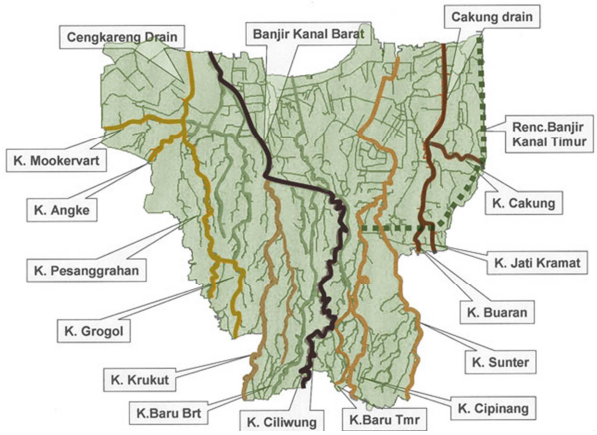

Figure.1.3: List of rivers in Jakarta [Pemprov DKI].

3.3 Population of DKI Jakarta

Since 1950, Jakarta has attracted the attention of many people

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from all over Indonesia. The large number of migrants came to Jakarta for economic reasons and job vacancies. Based on the 1961 census shows only 51% of the city's population is born in Jakarta. Megacity Jakarta increased from 11.91 million people in 1980, 17.14 million in 1990, and 20.63 million in 2000 to 28.01 million in 2010. In 2010, broader Jakarta accounted for 11.79 percent of the total population of Indonesia, but with this population is below 0.3 percent of the total area of the country. Jakarta has an estimated population of over 10 million people in 2016 as shown in Figure.1.4.

DKI Jakarta covers an area of 662.3 km2 of land area and 6,977 km2 of sea area. The Greater Jakarta metropolitan area has an area of 6,392 km2 as shown in Table.1.1. DKI Jakarta consists of five Administrative Cities as follows: Jakarta Pusat, Jakarta Barat, Jakarta Selatan, Jakarta Timur, Jakarta Utara as shown in Figure.1.5 and an Administrative Regency: Kepulauan Seribu.

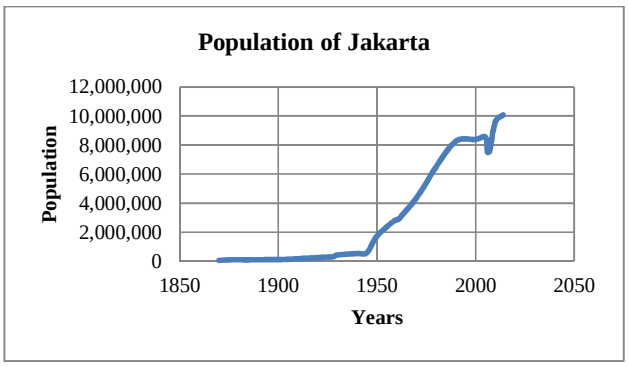

Figure.1.4: Statistic population of Jakarta in 1860 – 2014.

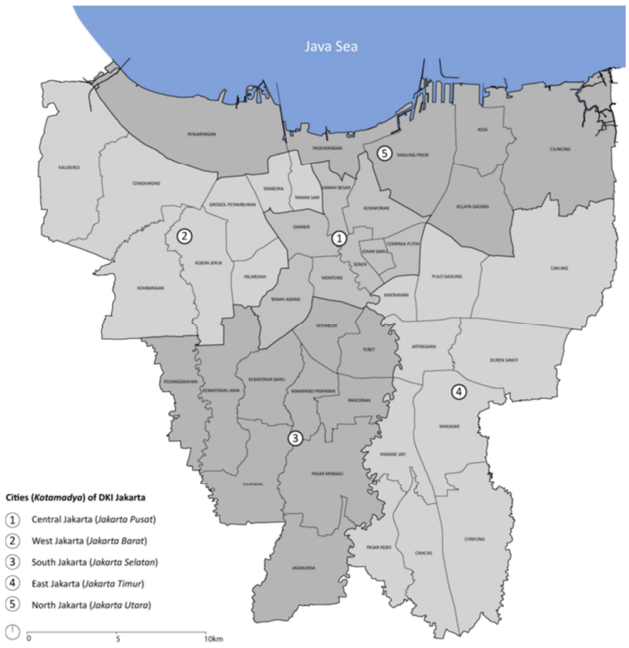

Figure.1.5: Map of the municipalities in Jakarta [DKI Jakarta].

Table.1.1: Jakarta's Municipalities

City/Regency	Area (km2)	Total population (2014)	Population Density (per km2) in 2014	HDI 2014 Estimated	HDI level
Jakarta Barat	129.54	2,430,410	18,762	0.797	High
Jakarta Selatan	141.27	2,164,070	15,319	0.833	Very High
Jakarta Utara	146.66	1,729,444	11,792	0.796	High
Jakarta Timur	188.03	2,817,994	14,987	0.807	Very High
Jakarta Pusat	48.13	910,381	18,915	0.796	High
Kepulauan Seribu	8.7	23,011	2,645	0.688	Medium

Note: Human Development Index (HDI)

3.4 Rivers Pollution

Since ancient times until now, the river has become an important part in human life. Around the world, rivers are used in addition to transportation, many people use the river for various purposes such as washing, bathing, sanitation, even cooking. There are also a variety of fish in the river that can be caught and consumed to meet the nutrients that humans need. It can happen if the river is clean and free of pollutants.

DKI Jakarta with all its prowess and beauty is very interesting to attract people to come. It has become the most popular urbanization destination. The city is crowded with too many people. This caused many residents to have difficulty in the settlement. Those who do not get home end up making semi-permanent homes in various places, one of which is the riverside

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land. The land along the river in Jakarta has turned into a slum. People inhabiting slum dwellings usually have a bad habit of throwing anything useless into a river. Because their house is right on the banks of the river so that any waste they produce will soon be thrown into the river.

Moreover, many other people also just pass the garbage carelessly. They do not realize that the waste will flow into the river. In turn, the river becomes filled with garbage and then undergoes siltation as shown in Figure 1.6. The shallowness of the river causes not able to accommodate the flow of water. When the rainy season arrives, the polluted shallow river will cause flooding. River water floods carry harmful bacteria that eventually cause many other diseases.

Figure.1.6: River pollution in Jakarta.

Among the rivers in DKI Jakarta, the most contaminated is the Ciliwung River. The river is accused of being responsible for annual flooding in several places in Jakarta. The quality of Ciliwung river water is highly polluted in all segments, from upstream: Puncak, Bogor to downstream: DKI Jakarta. River water discharges fluctuations in dry and rainy seasons are high enough to cause regular flooding in Jakarta. In May 2011, the Jakarta Environmental Management Board categorized all rivers in Jakarta as polluted; 71% were heavily polluted, 20% partially polluted and 9% tainted lightly.

Responding to the disaster, Jakarta City Government has made various efforts to reduce the risk and eliminate the impact. Among other efforts, the most intense activity was the revitalization of house pumping and river normalization in addition to the massive campaigns in order not to pollute the river.

4.0 BASIC THEORIES

4.1 Hydrologic Cycle

Originally water was constant in quantity and kept moving. There are parts that have been added or lost so far. The same water molecule has been transferred repeatedly from the oceans and the soil surface to the atmosphere by evaporation, falls on land as deposition, and is transferred back to the sea by rivers and groundwater. This endless circulation is known as the "hydrologic cycle".

Figure.1.7 shows the hydrologic cycle. The stages of the cycle are: evaporation, transport, condensation, precipitation, groundwater and run-off. In the process, water leaves the atmosphere and falls to earth as precipitation where it enters surface waters or percolates into the water table and groundwater and eventually is taken back into the atmosphere by transpiration and evaporation to begin the cycle again.

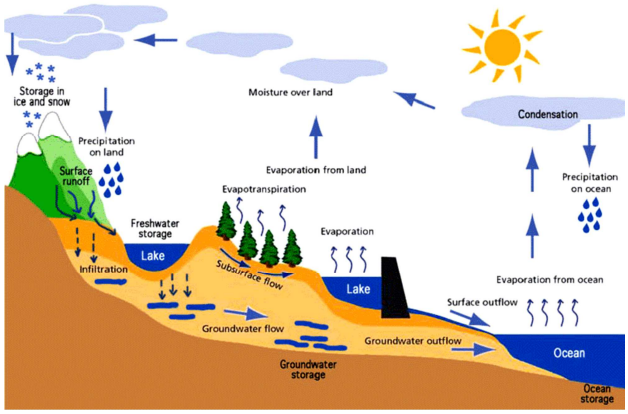

Figure.1.7: Hydrologic cycle [CES]

Evaporation

Water is transferred from the surface to the atmosphere through evaporation, the process by which water changes from a liquid to a gas. Approximately 80% of all evaporation is from the oceans, with the remaining 20% coming from inland water and vegetation [CES]

Transport

The movement of water through the atmosphere, specifically from over the oceans to over land, is called transport. Some of the earth's moisture transport is visible as clouds, which themselves consist of ice crystals and/or tiny water droplets.

Condensation

The transported water vapour eventually condenses, forming tiny droplets in clouds.

Precipitation

The primary mechanism for transporting water from the atmosphere to the surface of the earth is precipitation.

Groundwater

Some of the precipitation soaks into the ground and this is the main source of the formation of the waters found on land – rivers, lakes, groundwater and glaciers. Some of the underground water is trapped between rock or clay layers – this is called groundwater

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Run-off
Most of the water which returns to land flows downhill as run-off.

4.2 Debit of Rainfall
The volume of rainwater (V) is the same as the area affected by rainfall (A_{hujan}) in m multiplied by the amount of rainfall (q_{hujan}) in mm.

$$V = A_{hujan} \cdot q_{hujan} \quad (4.1)$$

4.3 Soil Absorption
Theoretically, flooding due to rainfall is due to flow and absorption actors. Flow is related to the ability or capacity of the river, while the absorption is related to the catchment areas or green spaces. The flood is also influenced by the water delivery factor of the buffer zone.

Soil absorption is easily illustrated as shown in Figure 1.8. If the soil is coarsely grained and porous as sand, the water will be absorbed. When rainwater drops the finer soil of the mud, its filtration capacity is reduced. Similarly, when rainwater falls on the clay, it is more difficult to absorb it.

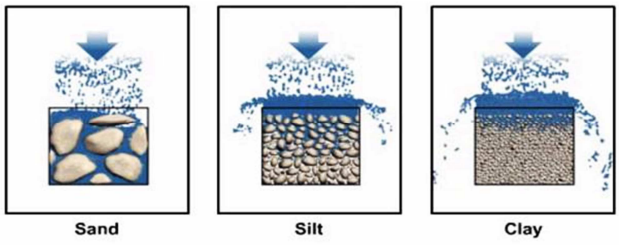


Figure.1.8: Soil absorption

When the rain water falls or well water canal or river water flow on the soil, some water percolates into and moves into inter spaces found between rock particulates as shown in Figure 1.9. The rain water that enters into the soil moves downwards. On its way, it fills up all the capillary spaces found in soil and still moves downwards by gravitational forces till it reaches the water table. Such water that goes downhill in the soil is called gravitational water.

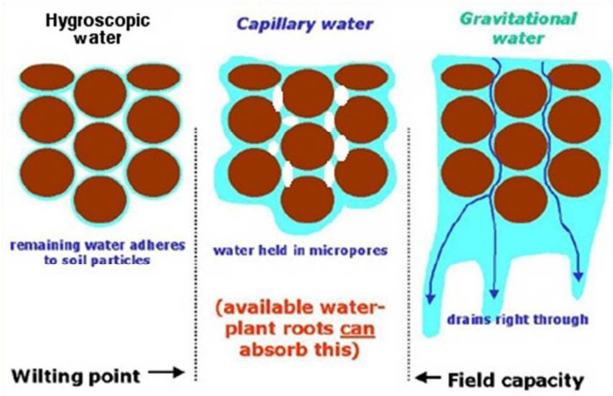
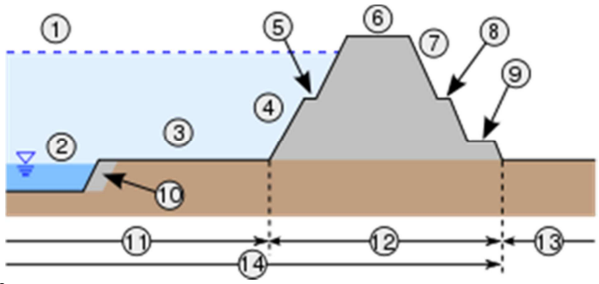


Figure.1.9: Absorption of water

4.4 Levee Dike Concept
A flood-bank or levee dike is an elongated naturally occurring ridge or artificially constructed fill or wall, which regulates water levels. It is usually earthen and often parallel to the course of a river in its floodplain or along low-lying coastlines. Basic layout of levee dike is shown in Figure 1.10 which has 14 components.



Note:
1.Design High Water Level (HWL), 2.Low water channel, 3.Flood channel, 4.Riverside Slope, 5.Riverside Banquette, 6.Levee Crown, 7.Landside Slope, 8.Landside Banquette, 9.Berm, 10.Low water revetment, 11.Riverside land, 12.Levee, 13.Protected lowland and 14.River zone

Figure.1.10: simple layout of a flood-bank

5.0 CHARATERISTIC OF RAINFALL IN JAKARTA

As many other cities, Jakarta has many urban problems. One problem is floods. Hazardous, annual floods inundate Jakarta every rainy season from December to February, engulfing tens of kilometers of residential city areas with up to four meters of sewage-infused floodwater for days. Floods occur repeatedly in DKI Jarkarta, usually during the rainy season. This phenomenon indicates a problem in water management in Jakarta. During the rainy season floods are common, while in the dry season water scarcity is a major issue. Effective water management ensures that the excess water during the rainy season does not cause disasters, whereas in the dry season, water that is primarily drinking water is adequately available.

Jakarta is a city prone to flooding with high rainfall resulted

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in flooding in some areas due to flow and absorption actors. Based on data retrieved from BMKG in 2011-2014, the rain starts in October to its peak in January and February as shown in Figure 1.11 and 1.12. In 2014, the rainfall was peaks at 1075 mm and 26 days. According to the Meteorology, Climatology and Geophysics Agency (BMKG), DKI Jakarta area was medium to heavy rain in February. Data from the DKI Jakarta Disaster Mitigation Agency (BPBD) showed the number of evacuees increased to 18 503. Floods on Tuesday drowned mostly areas in West Jakarta.

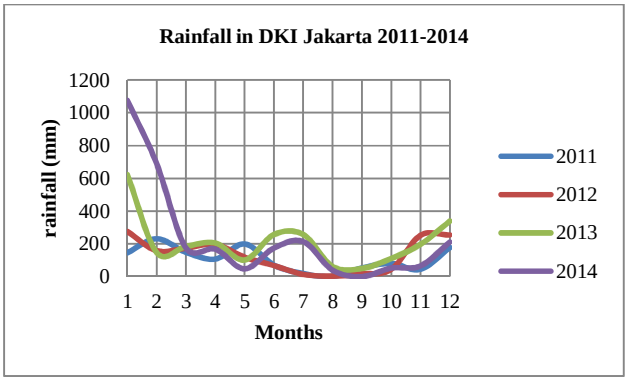

Figure.1.11: Statistic of rainfall in Jakarta in 2011-2014.

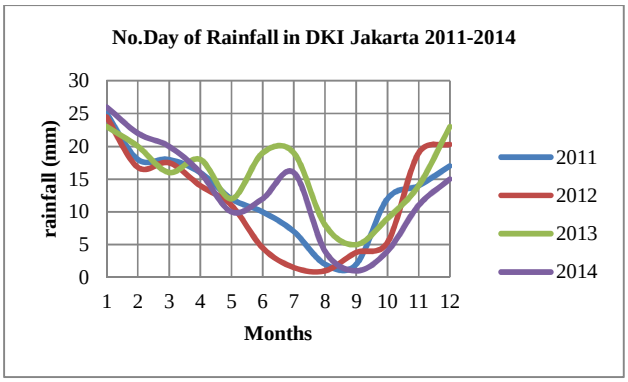

Figure.1.12: Statistic of number of day rainfall in Jakarta in 2011-2014.

Based on data from Indonesian Agency for Meteorology, Climatology and Geophysics (BMKG), in 2015-2016, rainfall in February is in the range of 100-150 mm per day, falling into the category of very dense. Figure.1.13 shows map of the rain distribution in JABODETABEK in 2015. JABODETABEK is an acronym from Jakarta-Bogor-Depok-Tangerang-Bekasi, a megapolitan area of Jakarta and its surroundings.

Under assumption rain evenly throughout Jakarta, the volume of rainfall in Jakarta can be calculated by using equation 4.1. Result of calculation is shown in Figure.1.14.

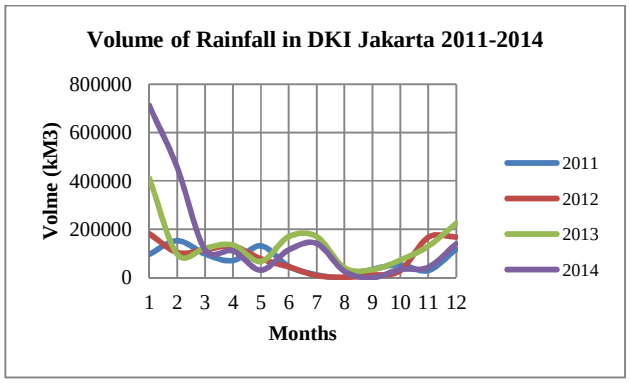

Figure.1.14: Volume of rainfall map in DKI Jakarta in 2011-2014.

6.0 EXISTING FLOOD PREVENTION

DKI Jakarta is repeatedly flooded when it rains, but below are some big floods in DKI Jakarta. Basically Jakarta flood caused by local rain, rob and flood shipment due to overflowing river water in the south or peak due to heavy rain.

- In February 1960, a flood occurred in a new area of Grogol. Although there are flood-proof plans in the suburbs of Grogol, the area is knee-deep and waist-deep. Another major flood was in 1996 when 5,000 hectares of land were flooded.
- In 2007, approximately 70% of Jakarta's total area was flooded with water up to four meters deep in parts of the city and at least 190,000 people have fallen ill due flood related illnesses.

Figure.1.14: Flood in DKI Jakarta, 2014 [BNPB]

Theoretically, flooding in Jakarta is caused by sea level rise during the rainy season combined with land degradation. On the other hand, floods caused by 13 rivers in towns that flow from the mountains prove a greater problem due to soil surface sedimentation. People living around the river have also contributed to pollution by dumping their daily garbage into the river.

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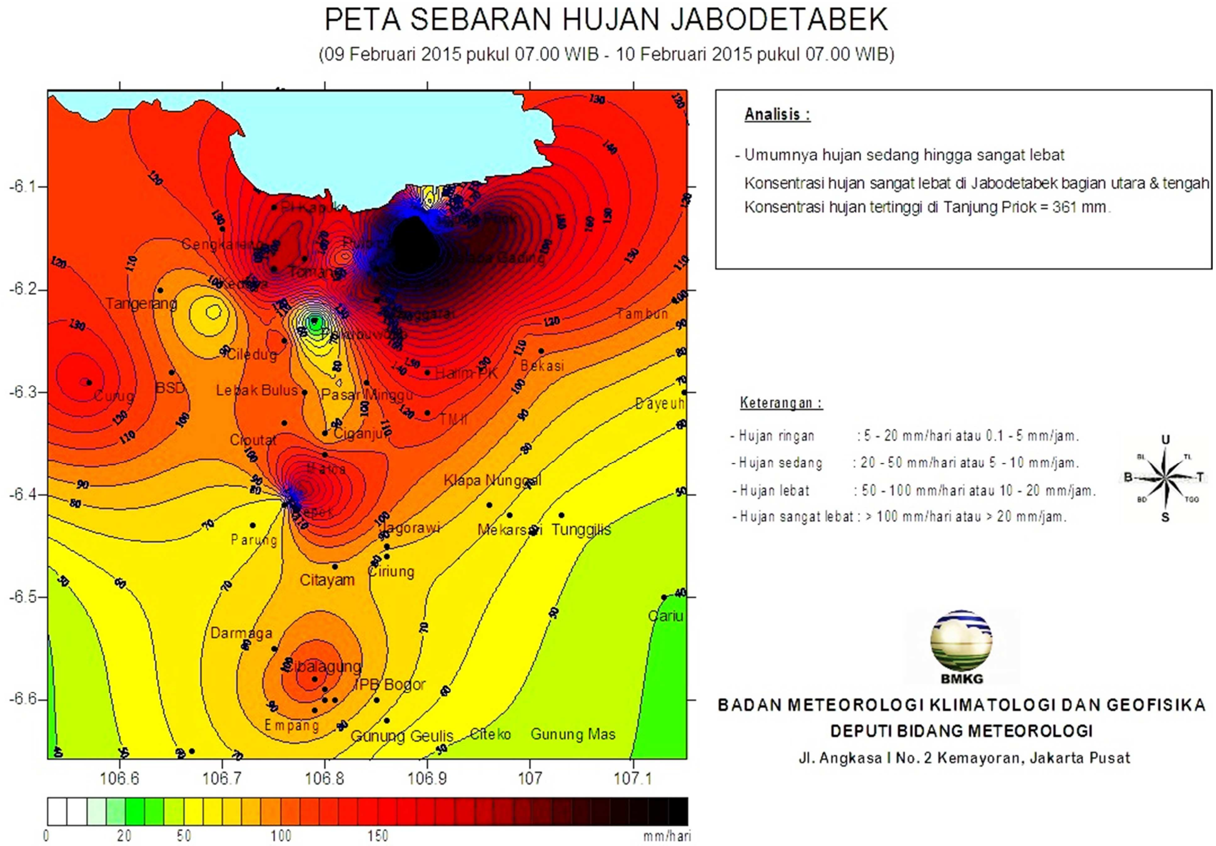

Figure.1.13: Rainfall map in DKI Jakarta in 2015 [BMKG].

In order to optimize the process of river normalization, the Provincial Government of DKI Jakarta may well make the following efforts:

- Build a flood retention basin (levee dike),
- River pumping stations,
- Dredging river regularly
- Developing a culture of clean river through education to the general public through broadcast television, radio, other social media and planting trees around the river,

6.1. Levee Dike

A feasibility study to build a levee dike on Jakarta Bay was carried out collaboration between Indonesia and Nederland. The government has enacted a raft and construction of the Great Wall of the Seas in an effort to prevent future floods as shown in Figure 1.15. The ring dike will be provided with pumping system and retention area, would regulate and control seawater and use also as additional toll road.

The Provincial Government of DKI Jakarta has made several efforts which install heap or river piles for hardening river walls, build new straight lane roads with shortest paths, and build embankments with landfills or concrete walls stretching in flood-prone areas.

Jakarta Flood Canal

The Jakarta Flood Canal refers to two canals that divert floods from rivers around Jakarta instead of going through the city. The canals divert the water flowing from the south around the city and into the sea. These canals are known as West Flood Canal (WFC) and East Flood Canal (EFC). Other measures to control floods in Jakarta include reservoirs and pumps in areas below sea level.

West Flood Canal

The West Flood Canal marked the southern boundary of the Menteng residential area. The flood canal was included in the 1918 Batavia city plan and constructed in 1919. It runs from the floodgate in Manggarai via Pasar Rumput, Dukuh Atas, Karet Kubur, Tanah Abang, Tomang, Grogol, and Pademangan to the sea at Muara Angke. Another floodgate is located in Karet. Figure.1.16 shows normalization using heavy equipment (excavator) to dredge muddy rubbish sludge in the Ciliwung River, West Flood Canal in DKI Jakarta.

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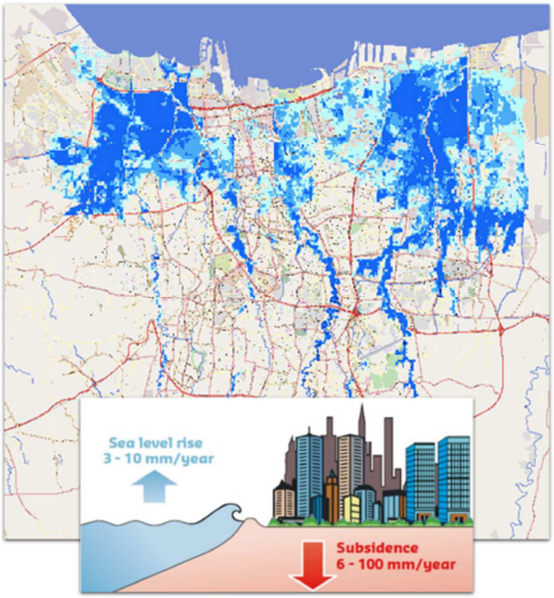

Figure.1.15: Jakarta's water challenges [HCC]

Figure.1.16: Ciliwung River Mud Dredging in DKI Jakarta [DKI Jakarta]

East Flood Canal

The 23.6 km East Flood Canal flows from East Jakarta to North Jakarta. The width of the canal varies from 100 to 300 m. Construction began on 22 June 2002, but has been delayed due to problems in clearing the area. The East Flood Canal is planned to divert the Ciliwung River, Cipinang River, Sunter River, Buaran River, Jati Kramat River, and Cakung River.

6.3. Flood Prevention Water Pumping Stations

As for the next natural disaster prevention measures, Jakarta City Government build a revitalization of house pumping and river normalization. Currently, pumping machines in Jakarta are 446 units spread over 150 pump locations.

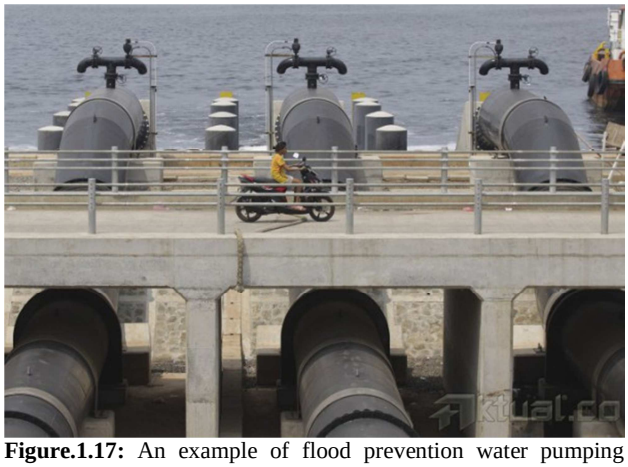

Figure.1.17: An example of flood prevention water pumping station in DKI Jakarta [DKI Jakarta]

After the construction of pump houses, management and repair is necessary. All pump houses must be well maintained in order to run well and smoothly when needed. The steps to be taken in the revitalization of pumps include repair of damaged pumps, replacement of used pumps and small capacity, optimizing pump support facilities, optimizing rivers, drainage channels and other waterways to support pump flow and discharge systems.

In addition, work coordination synergies between relevant local authorities are needed to pinpoint potential problems and solve existing problems quickly, improve regular and systematic monitoring and inspection, and ensure the cleanliness of the pump house environment to function optimally for pumping. Maintaining the cleanliness of drainage and drainage channels for pumping free machinery from potentially clogging sewage pumps is a necessity.

6.3. Dredging

River normalization is an attempt to return the river to its original function. Normalization is done when the river condition is shallow. This normalization requires periodically dredging aimed at extending and deepening the river.

Figure.1.18 shows normalization using heavy equipment (excavator) to dredge muddy rubbish sludge in the Ciliwung River, Pasar baru area, DKI Jakarta. Dredging is done to normalize the depth of the river so that the flow of water to function normally and to anticipate the danger of flooding in DKI Jakarta.

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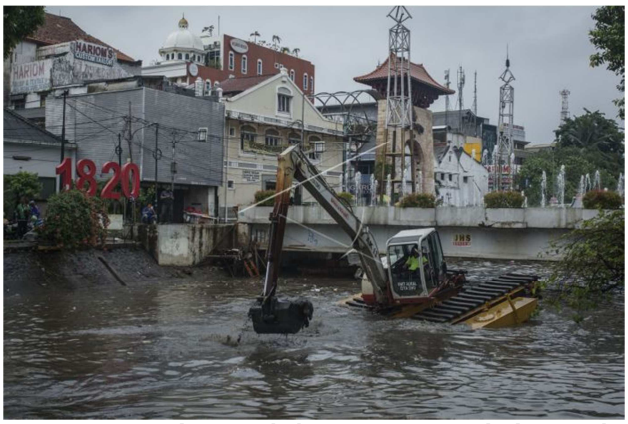

Figure.1.18: Dredging with heavy equipment dredge up the rubbish mixed garbage in the Ciliwung River, Pasar Baru area, DKI Jakarta [DKI Jakarta]

6.3. Proper Flood Management System

The Provincial Government of DKI Jakarta may appoint officers to manage infrastructure and channel facilities. Officers are responsible for dealing with waterways that have the potential to cause flooding or puddles, such as sewerage, clogged sewage and lack of drains. Infrastructure and Infrastructure Handling Officers are assigned based on incoming reports through Qnline application. Qnline is an application that deliberately made by the Provincial Government of DKI Jakarta to be used as a public complaint tool.

5.0 FLOODS IN DKI JAKARTA

The existing flood prevention program was made by the city government mentioned above do not give significant implications to the welfare of society. The program also does not provide solutions to overcome flood prevention in DKI Jakarta in which floods just happened such as at the end of 2017.

Figure.1.19: Floods occurs almost all of DKI Jakarta, 2017

5.0 CONCLUSION

In conclusion, this paper discusses on pro and cons the Jakarta government's plan for flood prevention. Positively, Jakarta government has done some good policies such as the development of flood retaining spaces, dredging activities for shallow water rivers, water pumps development and management team. On the contrary, the government has made an arbitrary eviction to the communities located around the river, causing humanitarian and political issues. It has found the existing flood prevention program was made by the city government mentioned above do not give significant implications to the welfare of society.

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