

Review Study on Rainfall Characteristics in DKI Jakarta

J. Koto,^{a,b,*} and Ridho Bela Negara,^a

^{a)}*Ocean and Aerospace Engineering Research, Indonesia*

^{b)}*Offshore Engineering, Faculty of Mechanical Engineering, Universiti Teknologi Malaysia, 81200 Skudai, Johor Bahru, Malaysia*

*Corresponding author: jaswar.koto@gmail.com & jaswar@utm.my

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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 discusses rainfall in DKI Jakarta to analyze flood during rainy season. It found that rainfall started from September to July. The peak season is on February in the range of 100-150 mm per day with a period of 23-25 days of rain. The volume of the raining on February 2014 was 700000 km³.

KEY WORDS: *Characteristics; Rainfall; Jakarta.*

NOMENCLATURE

WFC	West Flood Canal
EFC	East Flood Canal
DKI	Daerah Khusus Ibukota
BMKG	Badan- Meteorologi-Klimatologi- Geofisika
JABODETABEK	Jakarta-Bogor-Depok-Tangerang-Bekasi
BPBD	Badan Penanggulangan Bencana Daerah

1.0 INTRODUCTION

The high rate of urbanization in DKI (Special Capital Region) Jakarta has caused many problems such as unemployment, crime, economic equality, housing, floods, traffic congestion, poverty, slums, clean water and urban planning. Other than that, DKI Jakarta also faces some unique water infrastructure challenges, caused by 13 rivers such as Ciliwung, Kalibaru, Pesanggrahan, and other rivers. The topography of Jakarta is problem that the large expanse of the city sits below sea level, with some sinks 25 cm per year with an average of 5-10 cm as shown in Figure.1.1.

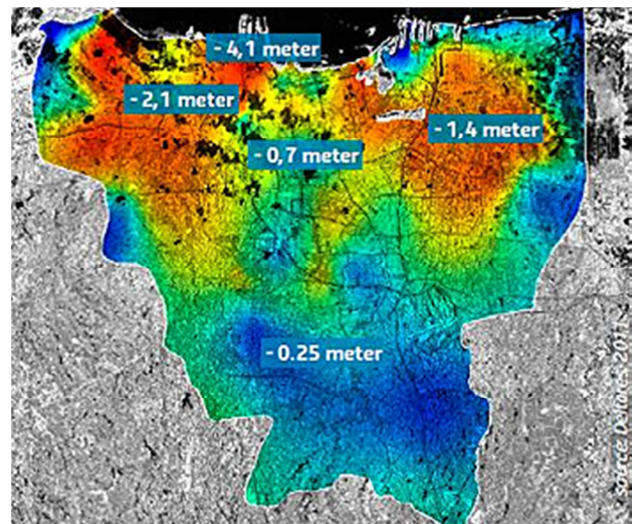


Figure.1.1: Land subsidence in Jakarta in period 1974-2010 [Indonesian & Dutch].

Flooding is a perennial problem that happens every year 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. Flooding occurs on the northwest coast of Java, at the mouth of the Ciliwung River on Jakarta Bay. The floods have happened recently in 1996, 2002, 2007 and 2013, 2014, 2017. When rainy season, floods occur in Jakarta for various reasons and overlap, such as: rivers filled with garbage, clogged waterways, high river sedimentation, and overflowing seawater. Flood water mixing with garbage piles in the cramped residential areas can spur disease, including skin infections and diarrhea, especially in children under the age of 5.

2.0 CLIMATE CHANGE IN INDONESIA

Indonesia is the fourth most populous nation and a significant emitter of greenhouse gases due to deforestation and land-use change. Indonesia consists of nearly two million square km of land, most of which is covered by forests. However, deforestation and land-use change is estimated at 2 million hectares (ha) per year and accounts for 85% of the Indonesia’s annual greenhouse gas emissions. The combination of high population density and high levels of biodiversity together with a staggering 80,000 km of coastline and 17,508 islands, makes Indonesia one of the most vulnerable countries to the impacts of climate change. The overall observed surface air temperature in Indonesia has increased by approximately 1-3°C over the last century [Michael Case, et.al].

Indonesia’s economy is heavily dependent on these natural ecosystems and their resources but there are threats to their sustainability. Current threats include Indonesia’s increasing population and rapid industrialization, such as large-scale deforestation and wildfires, land conversion and habitat destruction, overexploitation of marine resources, and a multitude of environmental problems associated with rapid urbanization and economic development and now climate change. Climate change threatens not only to exacerbate the aforementioned issues, but also create new ones, some of which are already taking place.

Indonesia has a tropical climate, with two distinct seasons; monsoon wet and dry. The rainy season is usually from November to April, with some regional variations. Jakarta as capital city of Indonesia has the heaviest rainfall from January to February. Average annual rainfall varies greatly with the lowlands receiving about 1.7 to 3.1 cm and the mountainous regions getting up to 6.1 cm. Average annual temperature is less variable and ranges from 23-32 °C.

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.1.2, 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

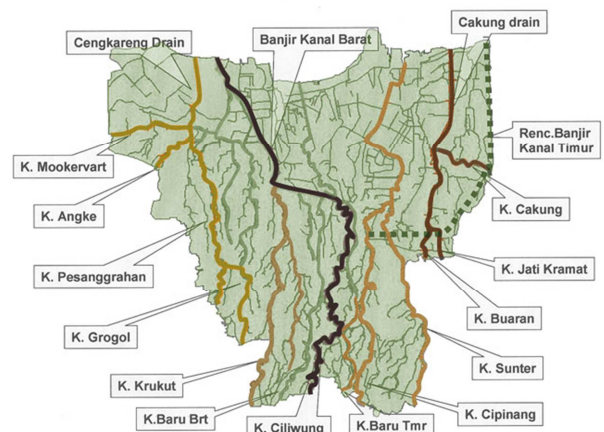


Figure.1.3: List of rivers in Jakarta [Pemprov DKI].

3.0 Population of Jakarta

Since 1950, Jakarta has attracted the attention of many people 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.

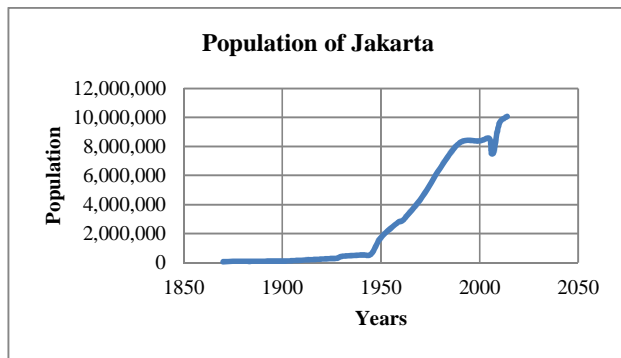


Figure.1.4: Statistic population of Jakarta in 1860 – 2014.

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.

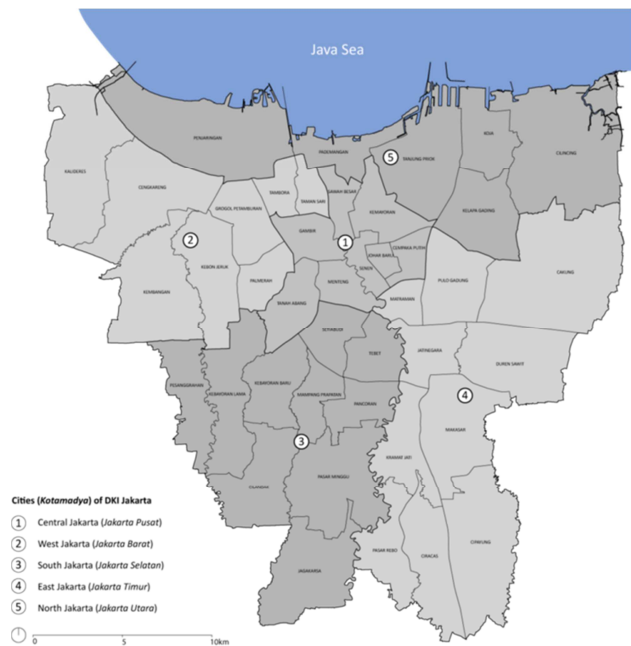


Figure.1.5: Map of the municipalities in Jakarta [DKI Jakarta].

4.0 RAINFALL THEORY

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"

Table.1.1: Jakarta's Municipalities

City/Regency	Area (km ²)	Total population (2014)	Population Density (per km ²) 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)

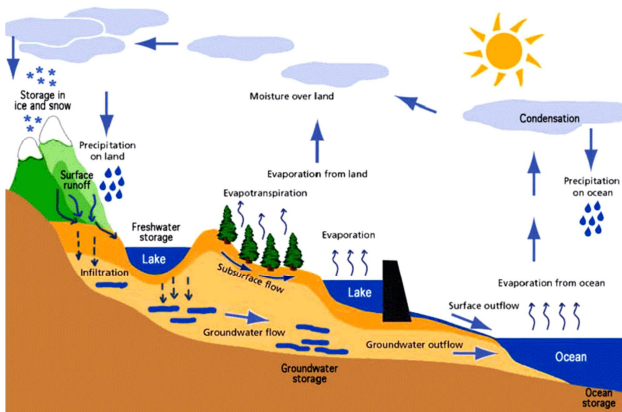


Figure.1.6: Hydrologic cycle [CES]

Figure.1.6 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.

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

Run-off

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

4.3 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.

$$V = A_{hujan} \cdot q_{hujan} \tag{4.1}$$

4.2 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 1.7. 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.

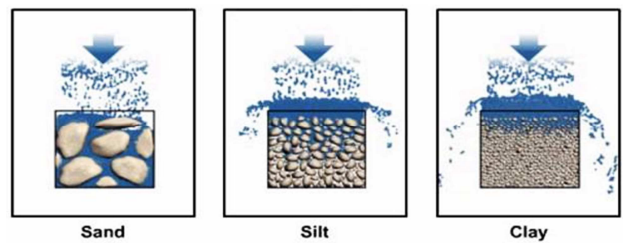


Figure.1.7: Soil absorption

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 1.8. 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.

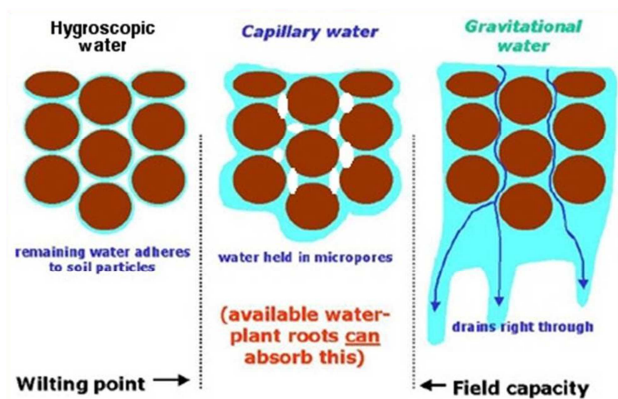


Figure.1.8: Absorption of water

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

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 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 1.9 and 1.10. 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 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: Flood in DKI Jakarta 2014 [BNPb].

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.1.11 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.1.12.



Figure.1.9: Statistic of rainfall in Jakarta in 2011-2014.

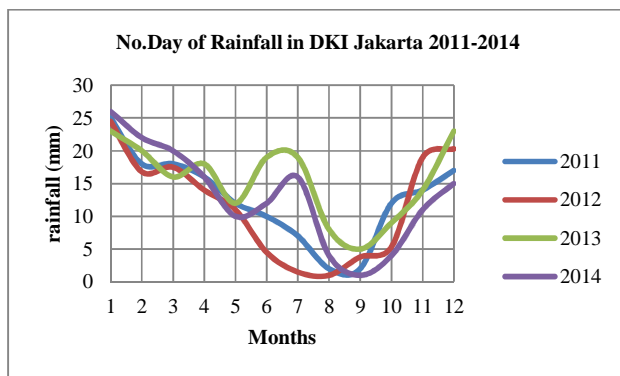


Figure.1.10: Statistic of number of day rainfall in Jakarta in 2011-2014.

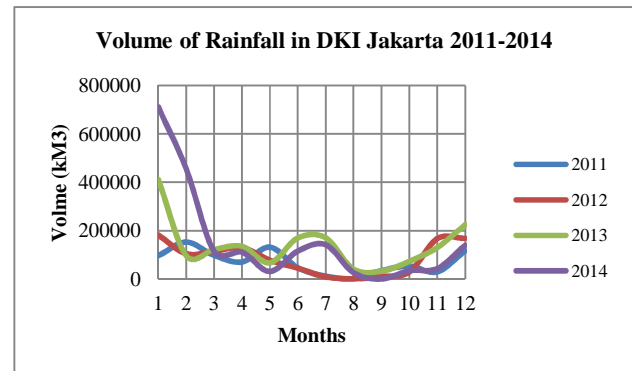


Figure.1.12: Volume of rainfall map in DKI Jakarta in 2011-2014.

5.0 CONCLUSION

In conclusion, this paper discusses on characteristics of rainfall in Special Capital Region of Jakarta. It found that rainfall started from September to July. The peak season is on February in the range of 100-150 mm per day with a period of 23-25 days of rain. The volume of the raining on February 2014 was 700000 km³.

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PETA SEBARAN HUJAN JABODETABEK

(09 Februari 2015 pukul 07.00 WIB - 10 Februari 2015 pukul 07.00 WIB)

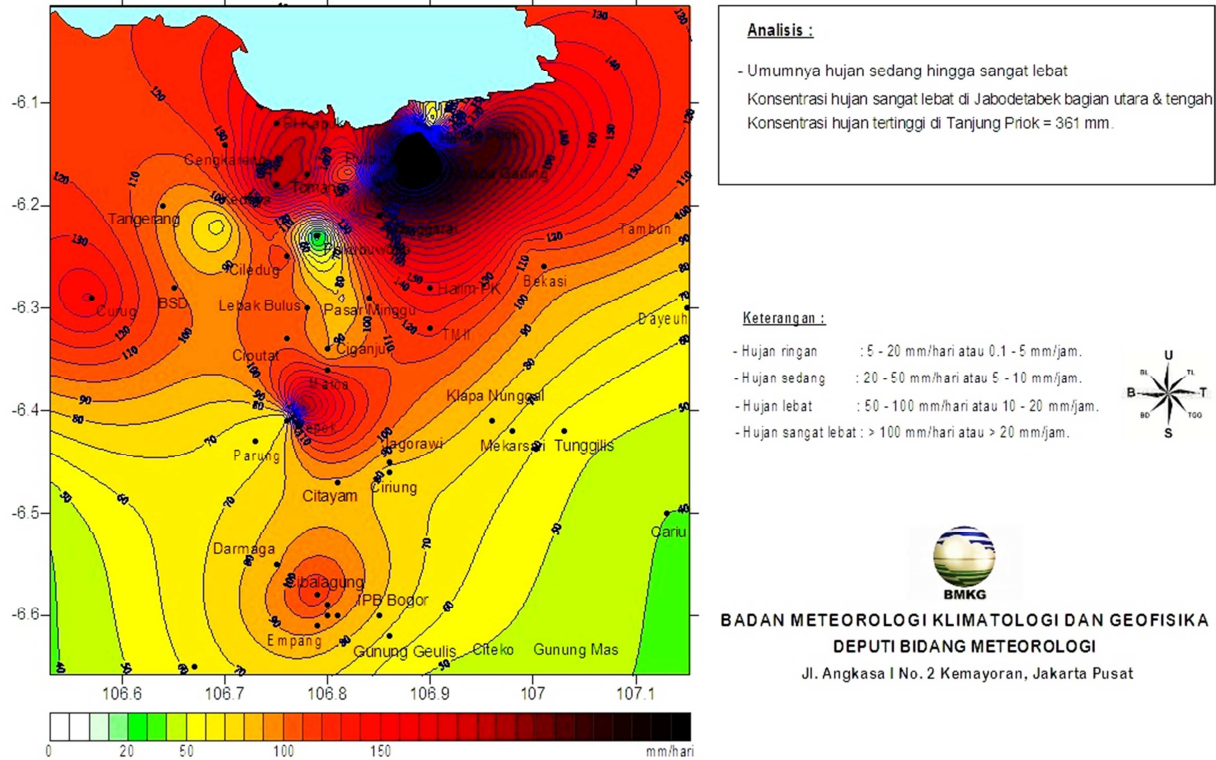


Figure.1.11: Rainfall map in DKI Jakarta in 2015 [BMKG].

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