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THE ROLE OF WATER SUPPLY AND SANITATION DURING FLOODS: CASE STUDY OF FLOOD DISASTER IN FIVE REGIONS OF JAKARTA

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ABSTRACT
Jakarta lies in low-lying deltas served by the Ciliwung River and many other small rivers. Due to overpopulation in Jakarta, green open spaces are diminishing. Since infiltration capacities of land in Jakarta have decreased, surface runoff has become more extensive. As a result, Jakarta is often stricken by flood disasters which affect human life, property, and urban infrastructures. The objectives of this study are to identify and develop mitigation strategies during flood disasters for communities and urban infrastructures, including facilities that supply water for daily use as well as drinking water, and also sanitation facilities. Primary data was collected during field surveys, while secondary data represents information obtained from relevant literature. The results of this study show that the average height of water during flooding was about 1 meter, and the highest level reported as 4 meters. The time required to fully drain the flooding areas is typically about five days. However, the degree of damage to buildings and property is relatively minor during a flood. The study also reveals that residents who have lived in their houses more than 25 years generally had been hit by floods at least two times. Thus, these communities demonstrated that they had learned from their experiences to prepare themselves for future flooding to reduce the extent of damage, suffering, and loss. Public guidelines for mitigating damages caused by flood disasters should be developed and followed with communication and explanation to the communities within the various regions of Jakarta. The water supply facilities, such as reservoirs, and sanitation facilities should ensure that water tanks are made available to every shelter and campground, and that permanent public toilets are provided.

Keywords: Drinking water; Floods; Mechanism; Sanitation; Water supply

1. INTRODUCTION
Indonesia's geographical position as a tropical country in a seismic zone surrounded by many active volcanoes increases the country's risk for natural disasters and sensitivity for floods, drought, fires, tsunamis and other natural disasters. Since these experiences occur frequently with similar results, mitigation strategies can reduce the damaging effects as well as the risks. Jakarta, as the capital city of Indonesia, is characterized by a dense population and a variety of city infrastructures and facilities such as housing, social and health services, electricity, education, and transportation. Jakarta lies in low-lying deltas as part of the Ciliwung River basin. Therefore, Jakarta receives water that flows from surrounding hills and mountains towards the Java Sea.

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Over the last 10 years, Jakarta has faced several flood disasters and meteorologists forecast that the flooding experienced in 2002 would be repeated in 2007, 2012 and so on. However, the floods that occurred in 2008 surprised forecasters, indicating potential for more frequent flooding in the future.

In general, almost all Jakarta regions are characterized by a tropical climate and rainfall intensity tends to be relatively high from October to April. Temperature is constant during the year with high humidity that is typical of archipelago country surrounded by the sea.

There are 13 main rivers flowing through Jakarta and the Ciliwung River is the longest river, measuring 117 km. The river is divided into five regions dubbed Regions 1, 2, 3, 4 and 5 (Anonym, 2008). The water quality of the upstream area is better than the downstream area, and the region that flows through Jakarta is the worst. The water quality of other rivers in the area is not much different from the Ciliwung River.

Jakarta Environmental Institution Agency (Badan Lingkungan Hidup Daerah/BLHD) represents the local government and monitors surface water quality in rivers, lakes, and ground-water. The quality of rivers is measured with a Pollution Index (PI). Based on BLHD monitoring data (Anonym, 2005), all regions of the Ciliwung River are classified as moderate to heavily polluted. Additionally, 50% of monitored wells were found to be contaminated with E. coli.

Clean water is supplied by the Water Treatment Plant managed by PAM JAYA, the local government's company, which is operated by two private partners, PT Aetra Air Jakarta (Aetra) and PT. PAM Lyonnaise Jakarta (Palyja). PAM JAYA serves only 60.21% of the Jakarta community (Ali, et al., 2008). Meanwhile, 38% of the community utilizes groundwater as a water resource.

Many floods are caused by heavy rainfall, usually during summer storms. This scenario is especially common in mountainous areas. Creeks, ditches, and storm sewers can only carry minimal amounts of water. Even in natural settings, water overflows every one or two years when rains overload the channels. Flooding can be further aggravated when debris blocks the waterway. Urban development has changed the natural environment within the area. Pavements and roof-tops prevent less rainwater from soaking into the ground, and gutters and storm sewers speed the runoff to the channels. The pattern of streets and buildings has interrupted some of the natural drainage mechanisms and reduced the width of some channels. As a result, surface runoff flows quickly, and the drainage system becomes overloaded more frequently. The Board of County Commissioners in Boulder County identified three flood protection categories: before the flood, during the flood and after the flood (Mendez et al., 2002).

2. OBJECTIVES

The objective of this study is to identify and develop mitigation strategies for providing clean water, including drinking water, and adequate sanitation facilities, both during and after flood occurrences.

3. STUDY AREA

This study encompasses five regions of Jakarta: West Jakarta, South Jakarta, Central Jakarta, East Jakarta and North Jakarta. The five regions of Jakarta are shown in Figure 1.

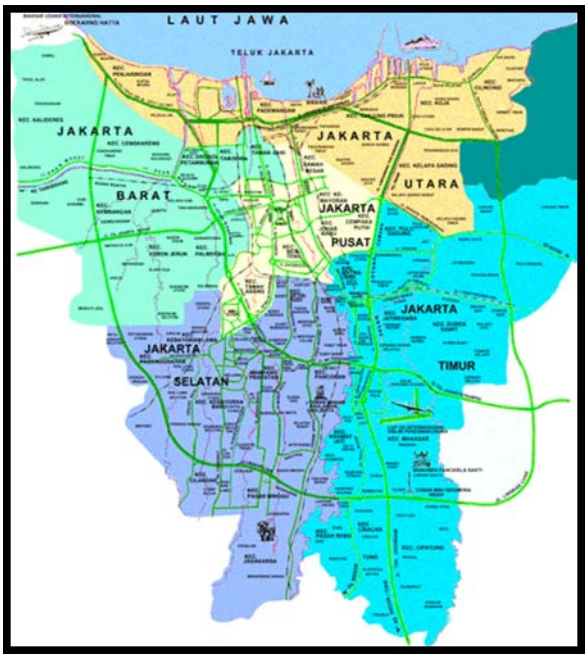

Figure 1 Map of Jakarta (http://www.dki.go.id)

Research was conducted within the Province of DKI Jakarta in several selected locations in the most frequently flooded areas influenced by several main rivers. The five regions are West Jakarta (Grogol and Cengkareng), North Jakarta (Kelapa Gading and Sunter), Central Jakarta (Senen, Cempaka Putih and Tanah Abang), South Jakarta (Tebet and Mampang) and East Jakarta (Jatinegara, Kampung Melayu, Cipinang Muara and Bidara Cina). The flooding in these locations is caused by overflows from the Ciliwung River, Kali Sunter, Kali Cipinang, Kali Pesanggrahan, Kali Angke and Kali Mookervart.

4. METHODOLOGY

This study employs an ex-post facto approach and a causal comparative method to observe several variables. The purposive sampling method is the appointed sampling method utilized in this study, and calculations reflect use of the Newbold equation and formula as follows:

$$n = \left[\frac{z_{\alpha/2}\sigma}{B} \right]^2 \quad (1)$$

where n is the number of sample(s); Z is the vertical line on $\alpha/2$ in normal distribution ($Z\ \alpha/2 = 1.96$); and B represents sampling error ($B = 0.06$ with confidence level of 95%).

Based on the Equation (1) above, the minimum number of samples required is 267. In this study, approximately 500 samples were taken, with an equal distribution of 100 samples taken from each region.

Field surveys and observations were conducted to collect primary data during the rainy season from September to November 2008. Secondary data represents information obtained by studying relevant literature.

5. RESULTS AND DISCUSSION

5.1. Floods experiences record

Several areas of Jakarta are critical to the study of flood disasters and are conducive to observation on aerial view Citra Landsat. Critical areas in West Jakarta include Cengkareng, Grogol, Petamburan, and Kalideres. The critical areas in South Jakarta are Kebayoran Baru, Mampang Prapatan, and Pasarminggu. The critical areas identified in East Jakarta are Cipayung, Ciracas, Kramatjati, and Makasar. Critical areas in Central Jakarta include Tanah Abang, Bendungan Hilir, Karet Tengsin, Kampung Bali, Kebon Melati, Blora and Kebon Kacang. Finally, the critical areas in North Jakarta are Kelapa Gading and Sunter.

Observations of survey respondents in South Jakarta show that communities of people have been living in the flood-prone area for about 25 years. Moreover, several respondents have been living there for almost 60 years.

In South and Central Jakarta, only 50% of respondents have lived in these regions for more than 25 years. Figure 2 shows that more than 60% of the respondents have experienced flood disasters. Approximately 90% of respondents living in East Jakarta have experienced floods, indicating that this region is the most frequently flood- inflicted area. In contrast, residents of South Jakarta are the least experienced in facing floods, with only approximately 61% of respondents reporting that they had experienced flooded conditions. This is due to the fact that South Jakarta is situated at a higher altitude than the other four regions. In addition, there are still substantial open green spaces in this region located in the upstream area.

Figure 2 shows the percentage of respondents who have experienced floods; East Jakarta obviously experiences more frequent flooding than the other regions. On the other hand, respondents from South Jakarta were observed as having the least experience with flooded conditions compared with other regions.

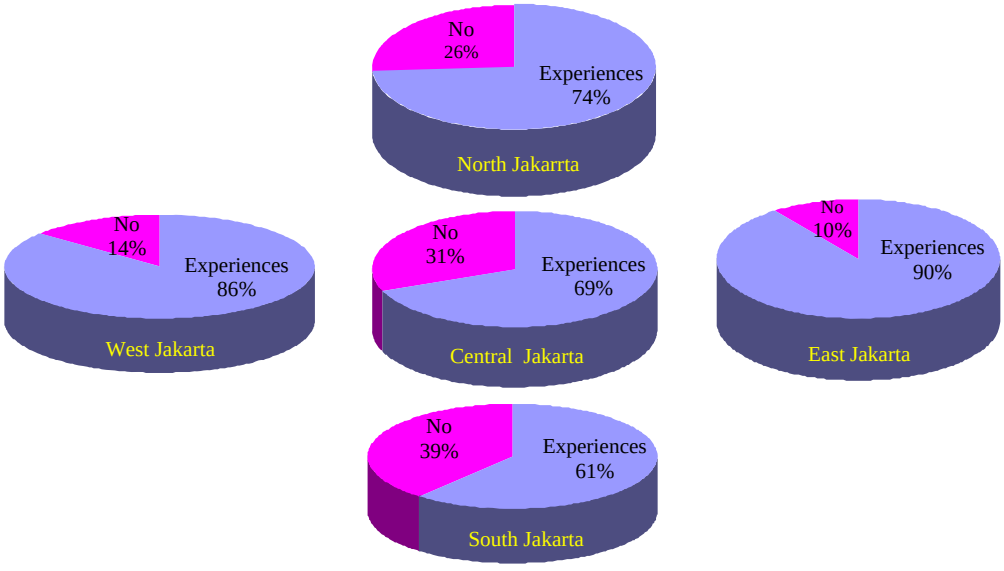

Figure 2 Percentage of respondents who experienced flood disasters in North, East, Central, West and South Regions of Jakarta

The average number of people living in each household in Jakarta is generally four to five persons. Almost every household in every region consists of more than four persons. Table 1 shows the typical length of stay and number of people in a house, based on a survey of 500 respondents.

Because of frequent flood experiences, certain communities have learned how to prepare proactively for floods. They have developed some effective strategies to reduce damage, suffering, and loss. Such strategies include heightening the ground floor level of a home, adding a second story, and utilizing attic space to store valuables during a flood. Such measures allow residents to evacuate when necessary and move valuables to the second floor.

Tabel 1 Length of stay and number of people in a house

Region	Number of families (stay > 25 years)	Number of families (> 4 people)
West Jakarta	100	100
South Jakarta	50	100
Central Jakarta	50	100
East Jakarta	100	100
North Jakarta	100	100

Table 2 below shows the typical height and width for houses in each region. All respondents living in Central and East Jakarta report house height as more than three meters, indicating an anticipation of floods with water levels as high as three meters. However, water level during flooding tends to increase, as demonstrated during the last flood event when the water level reached up to four meters.

Table 2 Height and width of respondents' houses

Region	Number of houses (Height > 3m)	Number of houses (Area > 40m^2)
West Jakarta	24	50
South Jakarta	48	100
Central Jakarta	100	100
East Jakarta	100	100
North Jakarta	48	100

The majority of respondents in each region receive their water from PAM JAYA, which seems to focus serious attention on important health issues. Their knowledge about the quality and benefit of clean water for drinking, daily use, and a healthy lifestyle is adequate. On the contrary, sanitation facilities supplying toilets and septic tanks were identified as having paid less attention to the respondents. Most respondents reported sharing toilets and using communal toilets for daily activities. This condition is shown in Table 3.

In Table 3, it is shown that a majority of respondents have access to water supplied from PAM JAYA, with the highest demand for water in West and North Jakarta (94%) and the lowest in South Jakarta (70%). It was noted that the population of South Jakarta generally prefers to use groundwater instead of PAM JAYA services, based on its better taste, colour and quality. Also, the cost of groundwater supply is less expensive than water supplied by PAM JAYA. On the other hand, residents of North Jakarta do not have the luxury of choosing between groundwater or PAM JAYA's supply because the groundwater's condition is brackish, contaminated and smelly. Some respondents do not use water supplied by PAM JAYA because they prefer to utilize wells or purchase a gallon of water (20 liter) and mineral water.

Table 3 Demand for water supply and sanitation facilities before floods

Region	Water supply from PAM JAYA (%)	Sanitation facilities (%)
West Jakarta	94	32
South Jakarta	70	14
Central Jakarta	93	18
East Jakarta	74	23
North Jakarta	94	27

Concerning sanitation facilities, only a few households are able to own toilets and septic tanks. For those who do not have access to sanitation facilities, a communal toilet is used. It was observed that few respondents own sanitation facilities because they live in areas close to the river which are densely populated and lacking in space to build septic tanks.

5.2. Conditions during and after flood events

Access to clean water, including drinking water, and sanitation facilities during flooding are a major issue. Several booster pumps and other supporting units located in the flooded area cannot function normally because the electricity supply is cut off for safety reasons by the National Electric Company. For those who are not PAM JAYA customers and rely on groundwater, the electricity cutoff totally severs their water supply. Moreover, the groundwater becomes contaminated by flood runoff and is deemed unsuitable for consumption. Local government and Non-Governmental Organizations (NGOs) work hand in hand to distribute bottled water to evacuation shelters, but some areas cannot be reached due to transportation difficulties and high levels of flood waters.

Flood disasters always have adverse effects, such as property damage, human suffering, and loss. Victims must move temporarily to base camps or shelters when their houses become inundated with water. They essentially become refugees living indefinitely in tents, schools, or other public facilities that were not affected by flooding. They frequently cannot go to work because of limited available transportation to dry during floods. Without electricity and income, non-formal workers or non-employees become very dependent on aids. Table 4 presents the percentages of various communities that received water and sanitation aids during flood disasters.

Table 4 The coverage of water supply and sanitation facilities during floods

Region	Water supply facilities (%)	Sanitation facilities (%)
West Jakarta	89	75
South Jakarta	17	14
Central Jakarta	80	18
East Jakarta	47	61
North Jakarta	69	81

Table 4 also indicates that the coverage of water supply decreased during flood events compared with normal conditions before flooding. On the other hand, coverage of sanitation facilities increased during periods of heavy flooding because of mobile sanitation equipment

provided by the government and NGOs. Additionally, people not adversely affected by floods lent their facilities to flood refugees.

Figure 3 describes the mental and emotional conditions of respondents during the flood events. Dominantly, it is apparent that victims experienced sadness when facing flood disasters. Additionally, several victims felt fearful and angry.

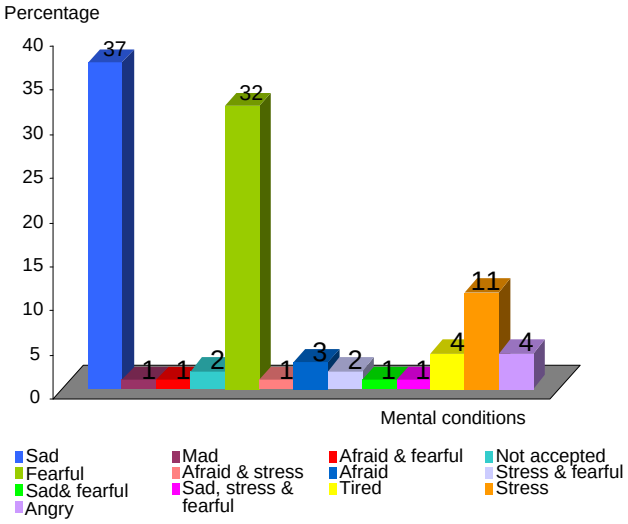

Figure 3 Mental conditions of respondents facing flood disaster

In order to successfully transition back to normal life, flood victims must learn to appropriate effective coping mechanisms. Surely, aids from the government, NGOs, and other communities will help victims cope with their sadness, anger, and fears. However, adequate supplies of food, clothing, water, and sanitation facilities represent significant deficiencies during floods. Since electricity always shuts down for safety reasons during flood disasters, people who use electrical equipment such as water pumps cannot access clean water. Government and l non-government organizations (NGOs) provide assistance by distributing mineral water to evacuation centres, but they are unable to reach all flooded areas due to the difficulties of transportation and high water levels.

Several water sources were utilized by respondents during floods, such as water supplied by PAM JAYA, individual groundwater wells, packaged water from mobile water tanks, and bottled mineral water. Respondents tried to obtain clean water from at least one source, but sometimes a combination of two different sources (such as from PAM JAYA combined with a groundwater source), to fulfil their water demands. Several respondents noted that water from PAM-JAYA exhibited high turbidity during flood periods. They also observed that the water treatment plant was unable at times to treat raw water to produce drinking water. The variety of water sources utilized by respondents can be seen in Figure 4 below.

In addition to the previously noted adverse effects of flooding on people and their property, floods damage the interiors and exteriors of buildings, as well as landscaping. Mitigation strategies in the form of physical and non-physical actions are needed to prevent or reduce potential damages. Physical action is represented by government programs and budget allocations. Non-physical programs include development of guidelines for dissemination to communities as part of a public information campaign in anticipation of future flood disasters.

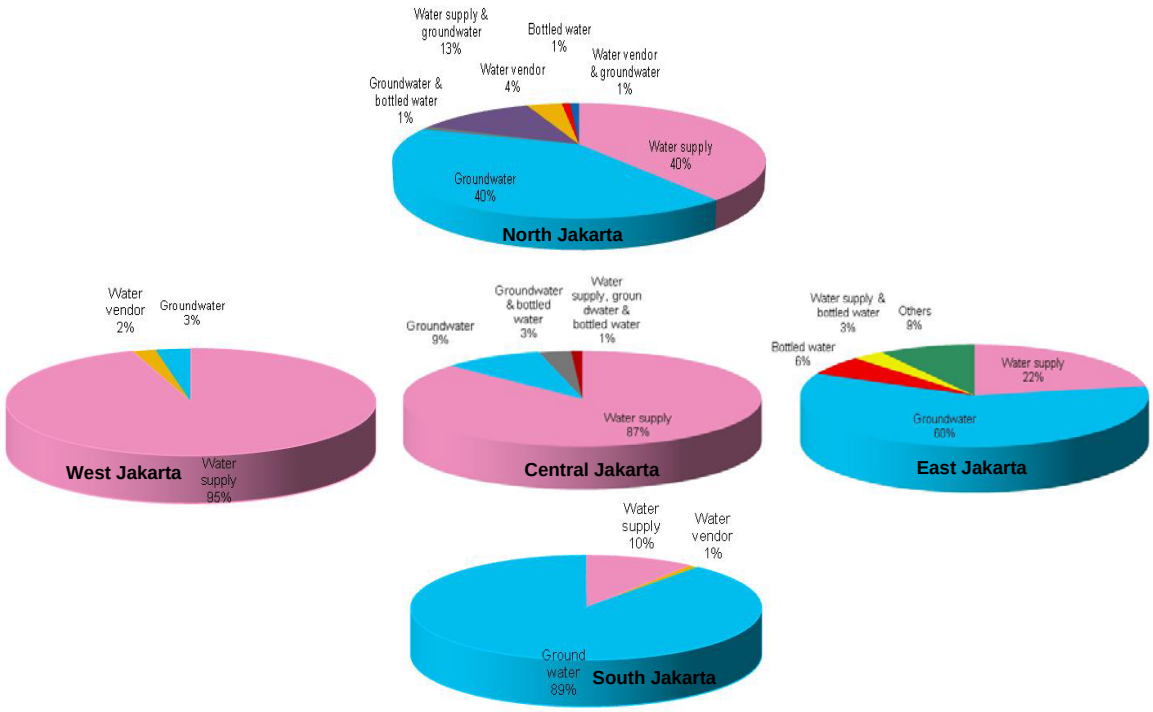

Figure 4 Utilization of various water resources by region

6. CONCLUSION

Community residents who have lived more than 25 years in flooded areas have demonstrated how to prepare for future flood disasters. The government must assist communities proactively so that flood risks are not ignored. Experienced flood victims have developed strategies to reduce damage to human life and property. One effective strategy, for example, is heightening the ground floor levels of their houses. Victims familiar with water shortages during flood disasters confirm that the number of water supply and sanitation facilities should be increased, as they are especially needed during floods. It was noted that, before a flood event, almost all community members received their water from PAM JAYA, and only a few people relied on wells or groundwater. Moreover, water quality should be improved to meet clean water standards. Government agencies, NGOs, and other communities can help flood victims by providing and distributing water and sanitation supplies.

In many locations, water supply infrastructures are not operating under normal conditions for quite some time following a flood. For example, PAM JAYA's private partners, as the city water operators, had not been able to fully repair water treatment facilities and distribution systems directly after the last major flood. Assistance and aids should be given to flood victims until normal operating conditions have resumed.

Central Government, local government, and the various communities should work together to develop an effective plan to prepare for future flood disasters. Flooding affects people and property; causes health problems, both physical and emotional; damages buildings and their contents; and landscaping.

Although there are 12 ponds to catch flood water in Jakarta, most of the ponds have lost their volume capacity because of sedimentation. Thus, they are in need of rehabilitation and

maintenance. Even though, flood control and rehabilitation are very expensive measures, the local government of DKI Jakarta will continue the canalization project in Jakarta and the surrounding areas known as the East Flooded Channel (Banjir Kanal Timur).

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