Second
REPORT

International Research Institute of Disaster Science (IRIDeS)

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"IRIDeS Fact-finding missions to Jakarta, Indonesia"
10 – 13 February 2013

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Second REPORT of IRIDeS Fact-finding mission to Jakarta, Indonesia
10-13 February 2013

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1. Executive Summary

From February 10 until February 13, 2013, an IRIDeS fact-finding mission consisting of five researchers visited Jakarta to make an initial assessment of the January 2013 flood, which made headlines due to its inundation of the country's presidential palace and its wealthy urban center, where unexpected casualties occurred. The team began to build relationships with national and local agencies and community organizations responsible for the city's flood preparation and response, and gathered data necessary for understanding the flood and for constructing a hydrologic/hydraulic model of the city's drainage system. The team also visited neighborhoods and interviewed residents affected by the flood, collected water quality samples of floodwaters and water in the city's drainage canals, visited sites of hydraulic structures along the drainage canals, and visited industrial parks to assess their flood protection measures.

The January 2013 floods are a complex problem because the rainfall intensity was smaller than that during the 2007 floods, yet Jakarta's wealthy commercial and governmental core, which escaped the 2007 floods, was inundated. This raises the various issues of increased runoff due to rapid urbanization and reduced drainage due to land subsidence (itself due to groundwater extraction and the weight of new construction). Also contributing to the flood may have been reduced capacity of the drainage system due to trash clogging flood gates, sedimentation reducing the depth of drainage canals, and illegal development of shantytowns in floodplains reducing the storage capacity of the system. Furthermore, breaching of a section of embankment along the west drainage canal flooded downtown areas below the canal. The canal embankment overtopping itself may have been the result of inconsistent embankment height (a locally lower embankment in the breach area) or/and seepage along the embankment/structure interface at a concrete structure (a highway bridge pier or a tower) built on the embankment at the breach site.

In addition to flooding due to the canal breach, it is also possible that downtown flooding was partially a result of operation of the Old Ciliwung gate at Manggarai, but this is unclear. Newspapers reported that this gate was opened in order to reduce water level in the west drainage canal, while the gate operator reported that the gate was never opened, but rather overtopped until the canal breach occurred downstream, thereby lowering water levels at Manggarai. Such contrary information was common during the team's visit, making reconstruction of actual events difficult. Similar contrary information was encountered regarding the problem of trash, which is a critical problem because clogging of the Karet gate (downstream of the canal breach site, and observed by Deltares during the flood) by trash may have been a principle cause of high water level at the canal breach site and at Manggarai gate, resulting in canal embankment failure and possibly Manggarai/Old Ciliwung gate overtopping and the ensuing flooding of Jakarta's commercial/governmental core. When asked why trash is disposed of in canals instead of collected properly by the city, government agencies stated that residents are lazy and need to be educated about the importance of proper trash disposal at designated government collection sites, and that due to the density of and narrow roads in illegal settlements along the waterways, trash collection trucks cannot access many of these communities to collect their trash. However, residents stated that the government does not collect trash in locations convenient to their neighborhoods, and so residents have no option other than to dispose of trash in the drainage system. Residents also suggested the government collect trash by barge or boat in waterside locations that trucks cannot reach. Such balkanization within and lack of trust among government agencies and between agencies and the public makes gathering facts and development of effective flood countermeasures difficult. However, all agencies, as well as the public, appeared very willing to talk to and share data and experiences with our team, as we are foreign and thus impartial to local infighting and partisan politics. The role of foreign organizations such as ours appears critical for forging cooperation among agencies and developing trust between the government and the public.

The team also investigated the causes of casualties due to the flood. Unexpected casualties, such as those which occurred when the underground parking area of the UOB building flooded, can be attributed to lack of a Standard Operating Procedure (SOP) for flood response, and the development of such SOP is a major goal of the current Governor's administration. Despite the lack of SOP, residents in frequently flooded areas (many of whom are illegal squatters) are developing their own flood response strategies, such as building multi-story homes and removing all important possessions from the ground floor. With the help of local community organizations, a questionnaire is currently being distributed to up to 700 residents to determine their individual responses to the flood and the effectiveness of the government's flood evacuation warning system. Initial results indicate that residents are reluctant to evacuate because they're concerned about the security of their possessions, or because there are no specified evacuation sites so they don't know where to go. Also important is the difficulty faced in relocating waterside shantytown residents to proper upland homes. Residents claim they live in waterside shantytowns because they can afford to (they need only pay minimal "rent" to bogus "landowners") and because living there is convenient for them (especially if they earn their livelihood by picking trash from the river and would otherwise have to commute to do this). They also claim life in the floodplain is not so bad, because they are only flooded 1 month of the year, so have the remaining 11 months to live normally, especially after adapting to the flooding by building 2-story homes. However, these illegal waterside shantytowns reduce the water storage capacity of the drainage system, and are the source of much of the trash that clogs the system.

Unlike after Jakarta's previous floods, deaths due to leptospirosis and dengue have not been reported this time, even though most of Jakarta's population has no access to sewage or septic systems, meaning that floodwaters inevitably contain much human waste. However, acute respiratory infections (ARI), diarrhea, gastritis, typhoid, and skin disease were common after the January 2013 flood due to continuous rain, cold living conditions, and lack of hygiene and sanitation in flooded and refuge areas. When asked how they view the danger of infection from floodwaters, many of the residents interviewed feel that since they were born and raised in unsanitary conditions, their immune systems are very strong and thus they will not fall ill even if they play or work in floodwaters. Analysis of water quality samples is underway to determine whether dilution of this waste with floodwater may have been a reason for the lack of leptospirosis and dengue in last month's flood. In addition to disease, the floods affected residents by interrupting the supply of clean water and electricity, and by temporarily putting affected health care facilities out of operation.

Many industrial parks are located in eastern Jakarta, where flood risk is considered lower than the in rest of the city, but insufficient local drainage has been seen to cause standing water, even while the water level in the eastern drainage canal was relatively low. Due to the recurrent flooding in Jakarta, private industries are implementing their own measures to reduce flood risk. For example, a Japanese industrial park has constructed a 1-m high floodwall around its periphery with sandbags stocked at the entrance gate for the guard to place if necessary, purchased pumps for evacuation of floodwaters and generators for emergency power, constructed stormwater retention basins, and elevated local roads to prevent flooding of transport routes. Guards working for the industrial park regularly check water levels as reported by BMKG, and run disaster preparedness drills. Individual industries do not face the same social obstacles to effective flood control that Jakarta as a whole faces, but even though industries have enacted their own effective flood countermeasures, they have been adversely affected by flooding of highways and streets throughout the capital, as this has prevented the transport of labor and goods, especially to key locations such as the port and airport.

In addition to all the above factors causing flooding in Jakarta, history plays a role as well. During Indonesia's colonial days, the Dutch founded their capital in a low-lying region near the sea because it was convenient as a port, because there was not a large settlement of native population there already, and because they held technical expertise at preventing flooding of low-lying river deltas. They constructed canals for drainage and dikes for protection from the sea, but their departure was followed by rapid urbanization and expansion of the urban area and neglect of maintenance of the drainage system. With foreign (Dutch and Japanese) assistance, the capacity of the drainage system has increased with the completion of the west drainage canal. An east drainage canal is also under construction, and will further increase the drainage capacity of the city, as long as maintenance and dredging are not neglected. Currently, Jakarta's entire drainage system, including canals and the Pluit sump, is undergoing dredging under the World Bank sponsored Jakarta Emergency Dredging Initiative (JEDI) project. Other measures such as a deep tunnel and surface detention basins for stormwater storage are being considered as well, though the effectiveness of these systems will also depend on continued maintenance and effective coordination among agencies and the public.

Many social, physical, and organizational factors were seen to have been responsible for the January 2013 Jakarta floods. The current goal of the analysis and modeling effort is not to suggest changes to the system, but rather to determine what is wrong with it as is. Has the design capacity of the system been reduced due to illegal development in the floodplain? Has trash clogged gates and resulted in backwater causing canal overtopping? Is much of the flood problem due to lack of maintenance? Are levees not providing the design level of protection due to crest subsidence and encroaching structures without proper structure-embankment transitions? The root of the problem needs to be determined before effective countermeasures can be enacted, and these countermeasures must be formulated incorporating both the physical and social causes of the problem. Through comprehensive analysis of social survey data, water quality data, rainfall and topography data, and hydrologic/hydrodynamic modeling, we will try to clarify the root cause of the 2013 canal overtopping and downtown flooding in particular, as well as the problem of Jakarta flooding in general.

2. IRIDeS fact-finding mission, plan, goals, and local collaborators

A team of 5 researchers from IRIDeS arrived in Jakarta on February 10, 2013 (Sunday), and left Jakarta the night of February 13, 2013 (Wednesday) with the mission of:

1. building relationships between IRIDeS and the national and local government agencies and community organizations responsible for flood response and affected by the city's floods, and
2. gathering facts and data related to the causes and effects of the city's flood problem.

The IRIDeS team consisted of:

1. Jeremy Bricker, Ph.D., P.E., Associate Professor, International Risk Evaluation Research Division
2. Shuichi Kure, Ph.D., Assistant Professor, International Risk Evaluation Research Division
3. Abdul Muhari, Ph.D., Postdoctoral Researcher, Tsunami Engineering Laboratory
4. Yo Fukutani, Research Associate, Tsunami Engineering Laboratory
5. Firmanto Hanan, Graduate Student, Disaster Medical Science Division

The specific goals of the team were to:

1. Build long-term relationships with collaborators and local agencies and organizations for mutual assistance in data collection and analysis.
2. Make a short-term qualitative assessment of causes of flooding.
3. Collect data on response of victims to the flood.
4. Collect data necessary for long-term, quantitative flood modeling.
5. Determine the possible causes of the west canal dike failure.
6. Assess the state of and performance of hydraulic structures in Jakarta's drainage system.

Local collaborators who accompanied the IRIDeS group were:

1. Mohammed Farid, Ph.D., Lecturer, Bandung Institute of Technology
2. Budianto, Ph.D., BPPT Jakarta
3. Hengki Eko Putra, RDI PT Asuransi MAIPARK Indonesia
4. Aditya RK, Ph.D., Postdoctoral Researcher, Tokyo Institute of Technology

The agencies with whom the IRIDeS team met were:

1. Indonesia Ministry of Public Works, via JICA expert Tanaka Takaya
2. Deltares (Dutch consultancy), via staff Hydrologist Daniel Tollenaar
3. National Agency for Disaster Management (BNPB), via JICA expert Tokunaga Yoshio
4. Indonesia Institute of Sciences (LIPI), via Ms. Irina Rafliana
5. Ciliwung River Community Organization, via Ms. Irina Rafliana
6. Jakarta Vice Governor's office, via staffer Michael Sianipar
7. Indonesia Agency for the Assessment and Application of Technology (BPPT), via Dr. Fadli
8. Jakarta Bureau for Gubernatorial Affairs and International Cooperation, via Mr. Heru
9. Jakarta Regional Agency for Disaster Management (BPBD), via Dr. Edy
10. Jakarta office of Tokio Marine
11. Pluit sump dredging operations monitoring manager, Dr. Heryanito
12. Indonesia Ministry of Health, Dr. Henni
13. Mangalai gate operator, Mr. Pardjono

Site visits included:

1. West canal dike breach site
2. North Jakarta flooded communities
3. Pluit sump
4. Mangalai gates
5. Mangalai upstream floodplain shantytowns
6. Industrial parks on Jakarta's outskirts

3. Background of the January 2013 Jakarta flood

A large flood occurred in Jakarta on 15-18 January 2013. The estimated flooded area was 41 km^2 with the flood depth ranging from 0.2 to 3.5 m. This event caused massive economic losses (preliminary statement from the Governor said around $1-2 billion) in addition to 19 casualties, and forced at least 18,018 people to stay in evacuation places. The provincial government declared a state of emergency through 27 January 2013. Similarly large floods had occurred during 2002 and 2007, but the 2013 flood was accompanied by a dike breach along the city's western drainage canal, leading to inundation of Jakarta's wealthy urban core and presidential palace, as well as unexpected casualties due to the rapidity of the resulting flooding.

4. Factors Contributing to the January 2013 Jakarta flood

4.1. Rainfall intensity

Heavy rainfall in and around Jakarta city due to the tropical monsoon may have been a main factor contributing to the 2013 Jakarta flood. Figure 4.1.1 shows the weekly rainfall [mm/7days] (Japan Meteorological Agency) over the world from 02/01/2013 through 16/01/2013. Heavy rainfall can be seen over Indonesia before and during the flood event (15/01/2013 – 18/01/2013). Figure 4.1.2 shows images of radar rainfall data (BPBS) in Jakarta city from 1/15 12:05 am through 1/15 7:05 am. It can be seen from these images that continuous heavy rainfall occurred over Jakarta city for more than 8 hours during the initial stage of the flood. Figure 4.1.3 shows the 2-day rainfall depth in Jakarta city obtained from GSMaP data (JAXA). GSMaP (e.g. Kubota et al., 2007) developed by JAXA is based on satellite-derived rainfall data. It provides hourly and daily rainfall data at 0.1-degree resolution for the whole world from March 2000 through today in nearly real time. From this figure, it was found that the during the 2013 flood, Jakarta experienced heavier rainfall than in other years. However, it should be noted that GSMaP provides satellite-driven rainfall data, and this data may have some uncertainties and biases. Figure 4.1.4 shows the 2-day rainfall depth in Jakarta city obtained from APHRODITE data (Japan Meteorological Research Institute). The APHRODITE dataset (e.g. Yatagai et al., 2012) is based on the spatial interpolation of ground observation data. It provides daily rainfall data at 0.25-degree resolution over the Asia and Pacific region from 1956 through 2007. From the figure, flood year 2002 shows the largest rainfall compared to the other years in Jakarta city. However, APHRODITE data is still not available for the period after December 2007. Also, spatial resolution of the data is 0.25 degree and this resolution is too coarse to evaluate the local rainfall over urban Jakarta.

It should be emphasized that only rainfall data obtained by rain gauges on the ground can accurately measure actual local rainfall. Figure 4.1.5 shows annual maximum 2-day rainfall depth at several rain gauge stations over the Ciliwung River basin in Jakarta city. It can be seen from these figures that some local rain gauges show large rainfall depth during the 2002 and 2007 flood years. However, we do not have rain gauge data yet for the 2013 flood. Therefore, historical rainfall data should be collected from all available rain gauge stations, especially for the wet periods of 2001-2002, 2006-2007 and 2012-2013 in order to evaluate the flood mechanism in Jakarta. These collected rainfall data will be used to clarify the characteristics of each flood in 2002, 2007 and

2013 by comparing against water levels, flood inundation maps, tide levels, ground water levels and land subsidence data. Furthermore, the data will be used as input to a flood inundation model, which will be developed in the near future, for the calibration and validation of the model. Also, long term trends in the rainfall data should be investigated in order to detect effects of urbanization and climate change impacts due to global warming.

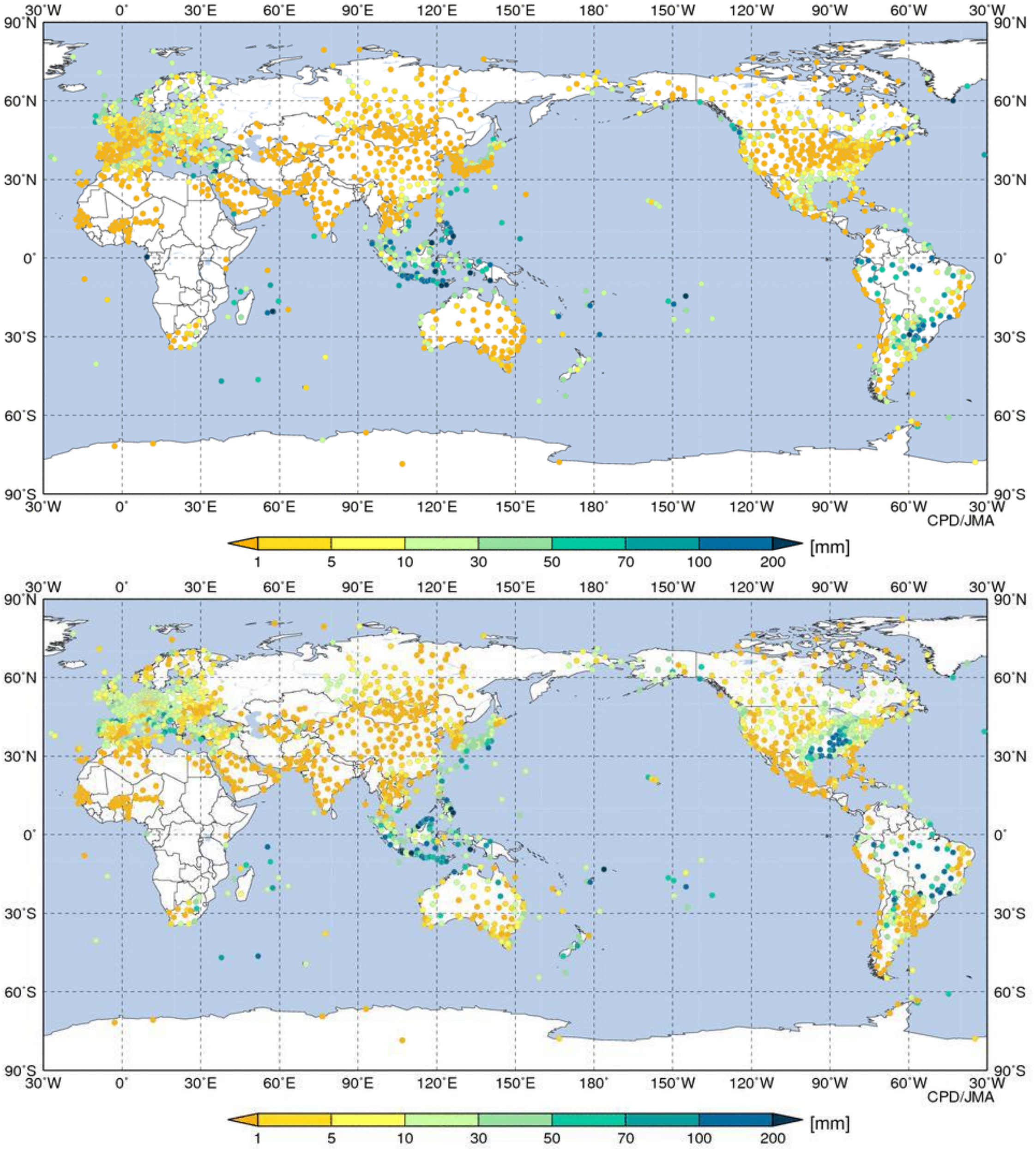


Figure 4.1.1. Weekly rainfall [mm/7days] (JMA) over the globe (Upper figure: 02/1/2013 - 08/1/2013 and Lower figure: 09/1/2013 - 16/1/2013)

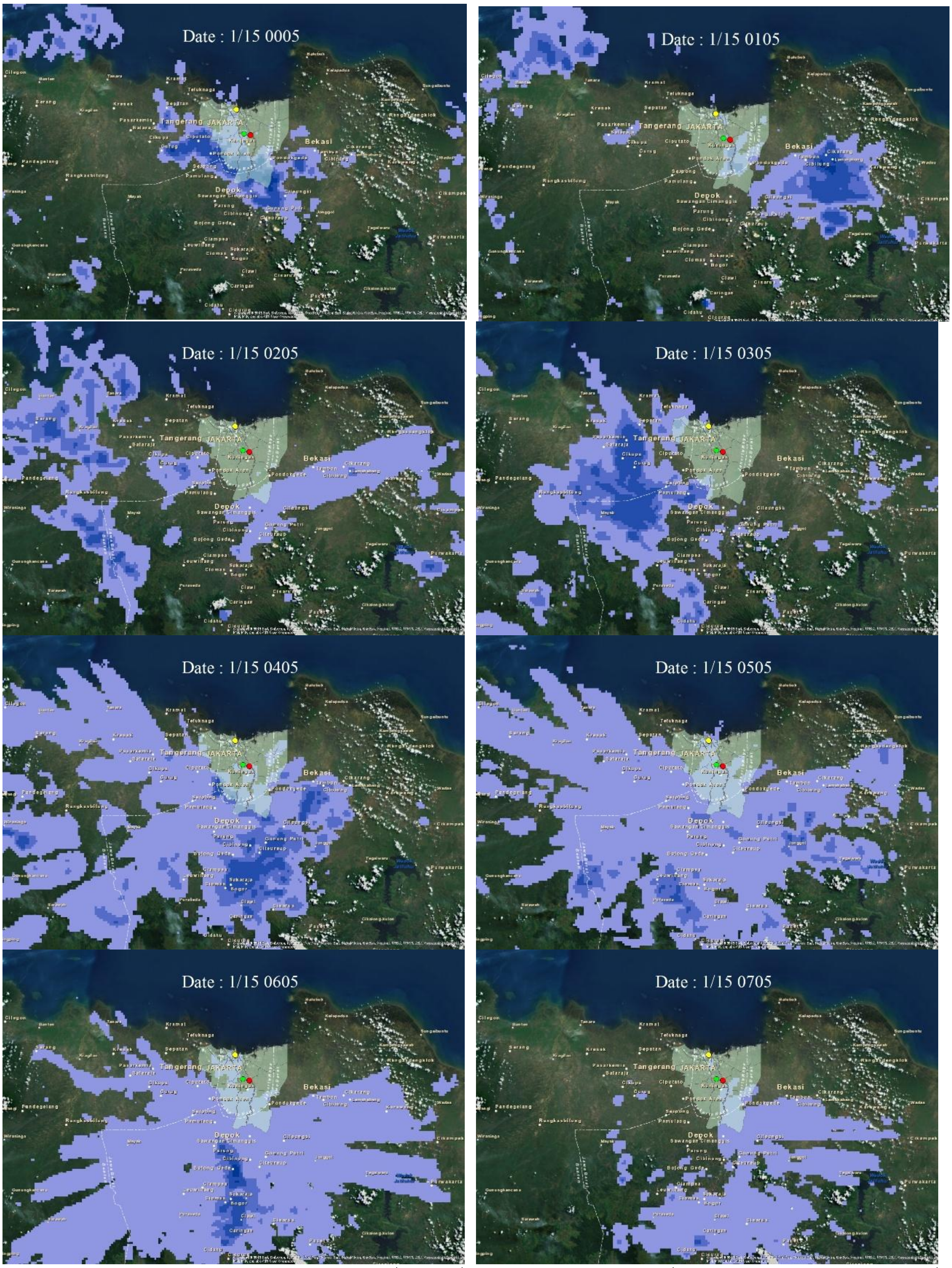


Figure 4.1.2. Radar rainfall images (BPBS) over Jakarta city (2013/1/15 12:05-7:05 am)

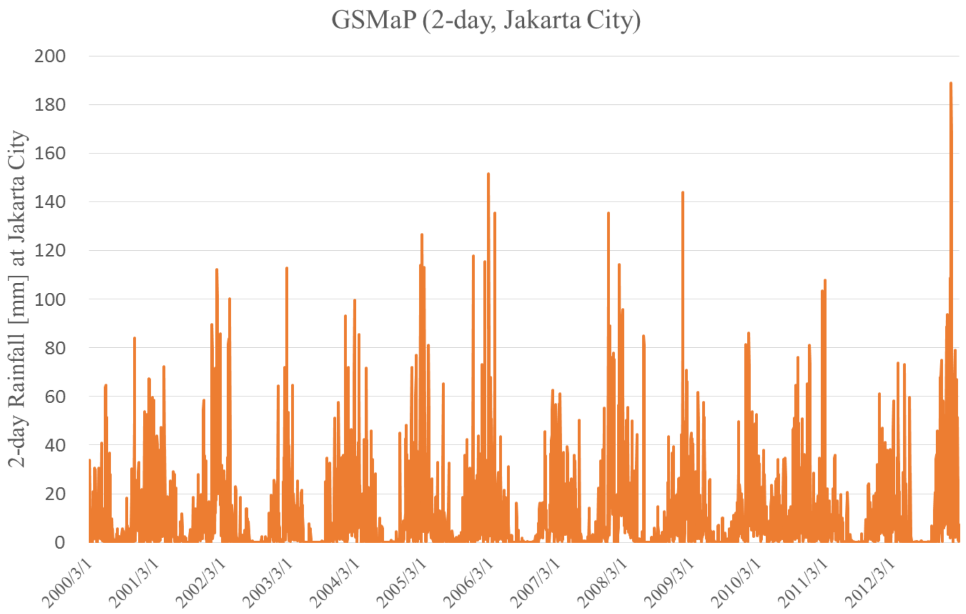


Figure 4.1.3. 2-day rainfall depth (GSMaP) in Jakarta city (2000/3/1 – 2013/2/28)

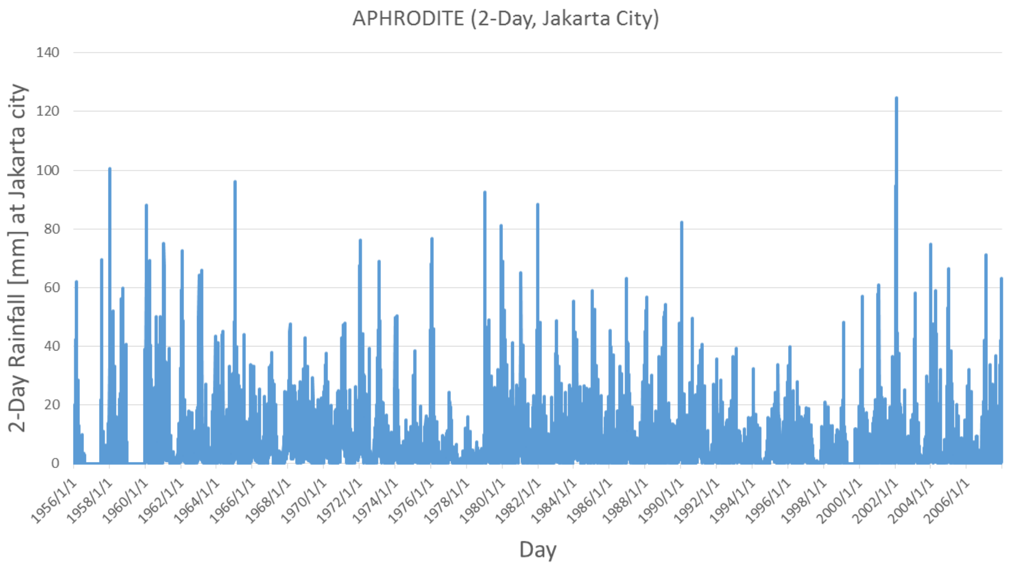


Figure 4.1.4. 2-day rainfall depth (APHRODITE) in Jakarta city (1956/1/1 – 2007/12/31)

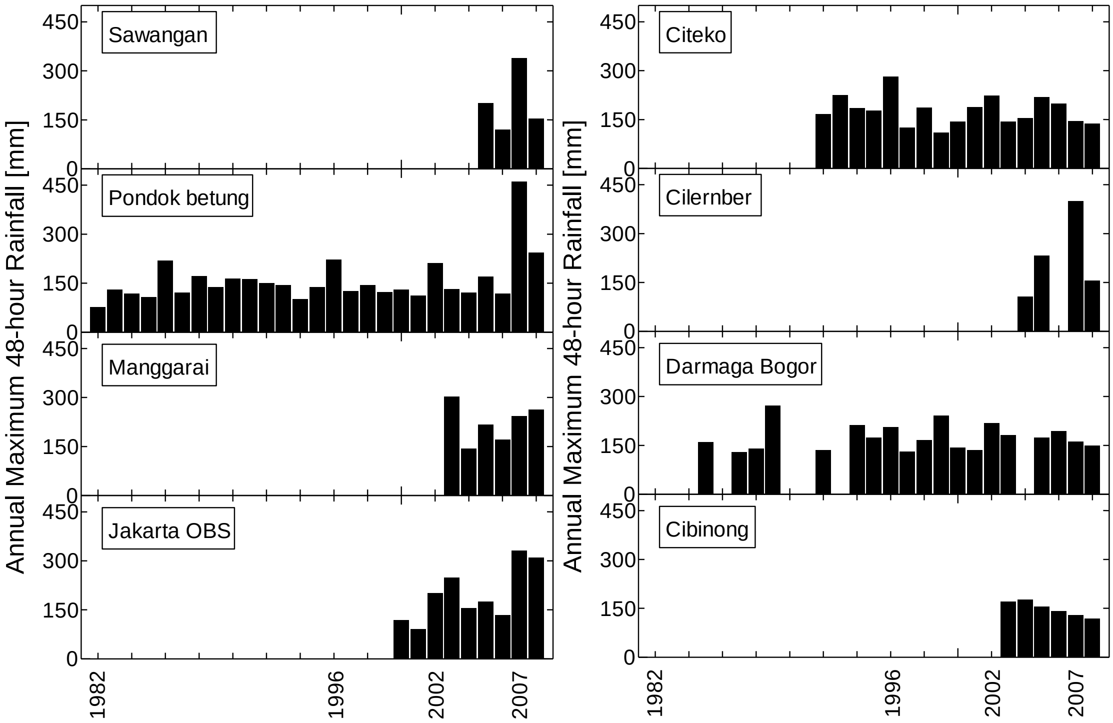


Figure 4.1.5. Annual maximum 2-day rainfall depth at several rain gauge stations over the Ciliwung River basin in Jakarta city (1982 – 2008)

4.1.1 References

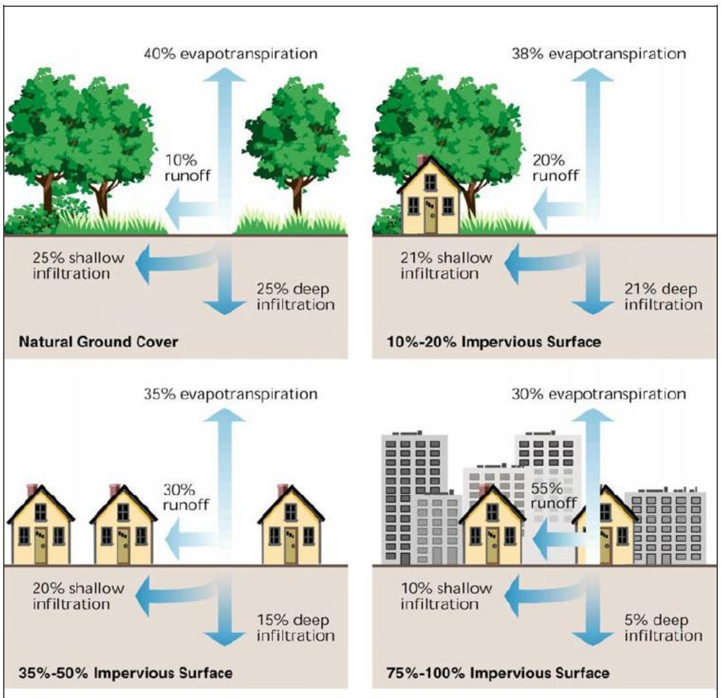
Kubota T, Shige S,HashizumeH,AonashiK, Takahashi N, Seto S, Hirose M, Takayabu YN, Nakagawa K, Iwanami K, Ushio T, Kachi M, Okamoto K. 2007. Global Precipitation Map using Satelliteborne Microwave Radiometers by the GSMaP Project: Production and Validation. IEEE Transactions on Geoscience and Remote Sensing 45(7): 2259–2275.

Yatagai, A., Kamiguchi, K., Arakawa, O., Hamada, A., Yasutomi, N. and Kitoh, A.: APHRODITE: Constructing a Long-term Daily Gridded Precipitation Dataset for Asia based on a Dense Network of Rain Gauges, Bulletin of American Meteorological Society, pp. 1401-1415, 2012, doi:10.1175/BAMS-D-11-00122.1.

4.2.Rapid urbanization

Rapid urbanization of Jakarta city due to economic growth and a rapid increase of the population in the city may be contributing to increase of the flood risk in Jakarta. Increasing flood frequency is considered to be one impact of urbanization. Urbanization has decreased Jakarta's permeable surface area and altered the city's surface runoff processes. Change in land use and land cover from vegetated to urbanized land has resulted in a reduction in water infiltration from the land surface to ground water and an increase the rainwater volume that directly contributes to runoff and flood through overland flows in the urban catchment area. As such, urbanization of the catchment has made floods larger and faster due to an increase of the effective surface runoff. The urbanization effect is illustrated in Figure 4.2.1. This figure describes the typical effect of deforestation and urbanization. The actual process depends on the location since various factors are involved.

Figure 4.2.2 shows land use cover maps of Jakarta city in 1980, 1995 and 2009. It can be seen from these figures that the land use in Jakarta city had dramatically changed since 1995, and almost the entire area of Jakarta city was urbanized by 2009. Therefore, the effect of urbanization on flooding in Jakarta should be quantitatively evaluated based on a physically based distributed rainfall runoff and flood inundation model. Based on the modeling results, some restrictions on land use/cover change in Jakarta city's development planning should be considered in the near future, and some measures such as a permeable paving of roads, deep wells for infiltration, etc that will increase rain water infiltration into the ground should be evaluated based on the model and should be considered for implementation in Jakarta city.



Source:
http://www.nrcs.usda.gov/technical/stream_restoration/Images/scrhimage/chap3/fig3-21.jpg

Figure 4.2.1. The influence of urbanization on different components of the water cycle

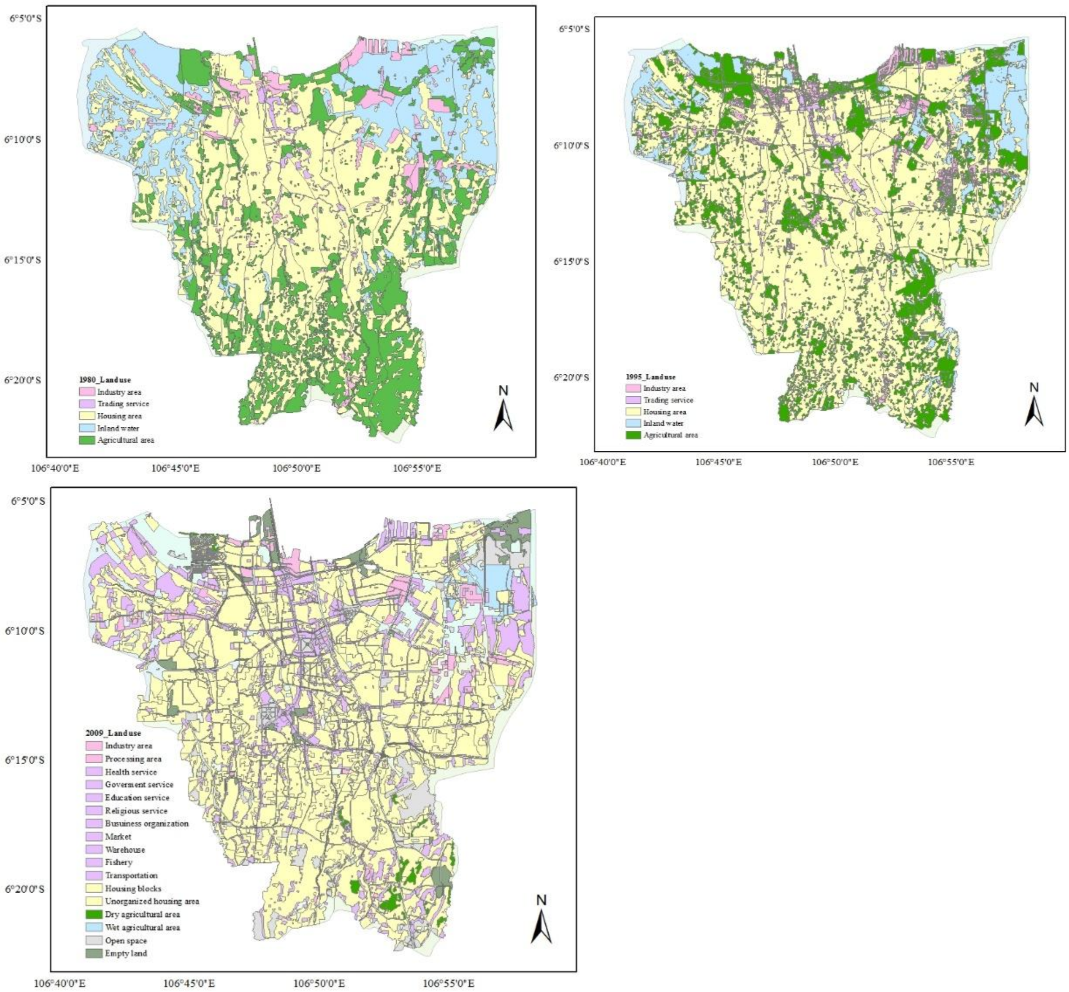


Figure 4.2.2. Land use cover map over Jakarta city (1980 (upper left), 1995 (upper right) and 2009 (lower)) (from BPBD)

4.3. Land subsidence

Land subsidence is widely known to be a significant problem contributing to urban flooding in Jakarta. Figure 4.3.1 shows the accumulated land subsidence in Jakarta city from 1974 to 2010. It can be seen from this figure that land subsidence ranging from 0.1 m to 4 m has occurred in the lowland areas of Jakarta during the past decades. This land subsidence may be contributing to urban flooding in these specific lowland areas. Many parts of the lowland areas are located bellow mean sea level, so these are easily inundated due to high intensity rainfall, and are difficult to dewater due to the need for pumps.

The effect of land subsidence on urban flooding in lowland areas of Jakarta should be evaluated based on a flood inundation model with several tide level scenarios. Furthermore, it is very important to identify the reason for land subsidence. Some people claim that this is due to the intensive withdrawal of ground water and/or rapid urbanization (the weight of structures upon the ground causing the ground to subside). The mechanism of land subsidence in Jakarta should be clarified as soon as possible, and quick action to stop land subsidence is necessary. Otherwise, the future risk of urban flooding will increase due to the continuous land subsidence coupled with sea level rise due to climate change.

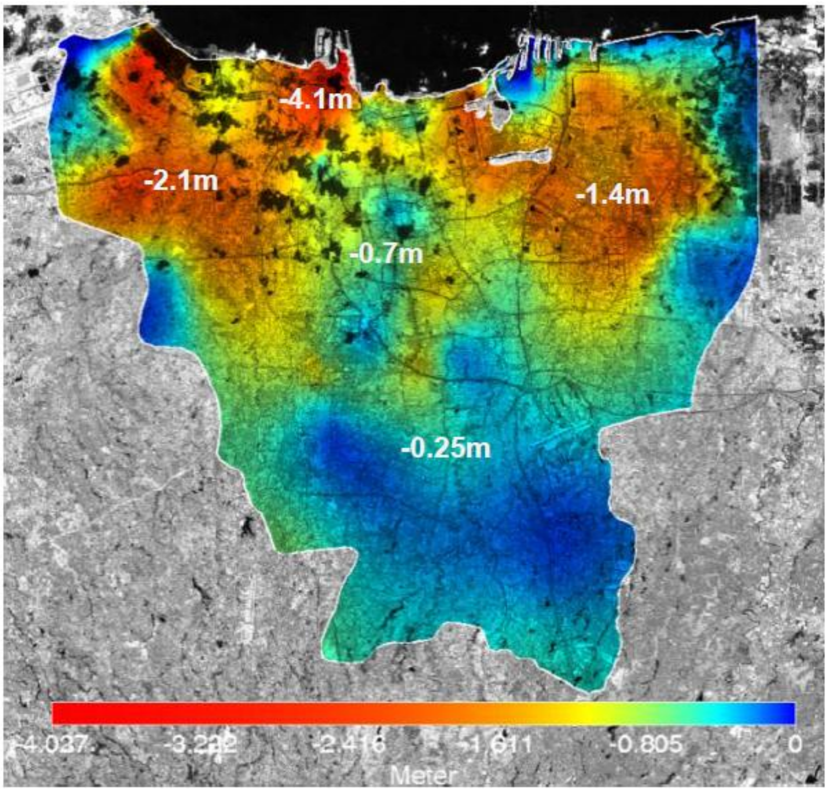


Figure 4.3.1. Accumulated land subsidence (m) in Jakarta city from 1974 through 2010 (from Ministry of Public Works)

4.4.Latuharhari embankment failure mechanism

Based on forensic evidence remaining, recorded water level data, and a simple scour analysis, it can be surmised that the mechanism of failure of the West Drainage Canal embankment at Latuharhari (Figure 4.4.1) was likely overtopping of the embankment's locally subsided crest followed by rapid scour of the embankment's landward slope, though seepage through the embankment along an encroaching structure (a bridge pier or tower) on the embankment crest may have accelerated this process. Figure 4.4.2 shows a schematic of the pre-breach embankment at the breach location, while Figure 4.4.3 shows water level at the Karet gate, which controls the water level in the West Drainage Canal at the breach location. At 10 am on January 17, the water level in the West Drainage Canal (Karet) rose to water level 1 as indicated on Figures 4.4.2 and 4.4.3, overtopping the embankment. Rapid flow over the steep landward slope of the embankment and subsequent head-cutting rapidly eroded the embankment away until the water level in the canal dropped to water level 2 in Figures 4.4.2 and 4.4.3, controlled by the masonry parapet wall about 20 cm lower than the original embankment crest. At 3 pm, the water level abruptly dropped another 30 cm to water level 3 of Figures 4.4.2 and 4.4.3 possibly due to the failure of the short masonry parapet wall that appears to have been in place in this section. The water level then remained constant until the breach was repaired on the night of January 18 or the morning of January 19. A forensic analysis of this failure mechanism, as well as elimination of the likelihood of other scour mechanisms, is detailed below.

A suggested countermeasure to prevent overtopping in the future is normalizing the embankment crest height along the entire length of the canal by bringing local depressions in the crest height up to the design elevation (this first requires manual inspection of the entire canal embankment to identify such sections). On the other hand, if overtopping is to be allowed, the landward embankment slope must be armored along the overtoppable canal sections, though this is a probably a more expensive option than normalizing the canal crest elevation. Either way, structures that encroach onto the water-side embankment slope must be either removed and backfilled or properly bulkheaded in order to prevent floodwater seepage through the structure-soil interface (again, inspection of the entire canal is necessary to identify such structures). Furthermore, flood-fighting should become a standard practice during flood events, with sandbag-equipped teams patrolling the entire length of the embankment until the threat is over. These teams should be responsible for reinforcing any weak or low spots before breaches occur.

4.4.1 Possible failure mechanisms considered

Initially, 4 independent mechanisms of failure had been considered:

1. Internal erosion due to suffusion through the embankment, or piping of water through a void in the embankment.
2. Displacement of the embankment due to construction upon soil of insufficient shear strength.
3. Bank erosion of the unarmored water-side slope of the embankment, due to energetic flow in the canal.
4. Overtopping of the embankment followed by scour of the landward slope, causing headcutting back to the embankment crest, followed by complete scour of the embankment. A hypothesis related to this is the possibility of seepage of flow at the concrete-soil interface where a highway bridge pier stands on the embankment, resulting in local scour that allowed overtopping to occur.

A detailed analysis of each of these mechanisms resulted in the elimination of internal erosion, displacement, and bank erosion of the water-side slope as likely mechanisms. Overtopping (possibly accelerated by seepage along an encroaching structure) is the likely cause of failure. The feasibility of each of these mechanisms is considered below.

4.4.2 Feasibility of internal erosion as a cause of failure

The first mechanism considered, internal erosion, is generally unlikely because the embankment material is mostly silt and clay (see Attachments 4.4.1 – 4.4.3). Suffusion, though a frequent worry in sandy soils, is less common in materials like silt and clay with low permeability. Suffusion is especially unlikely because the embankment was only wetted above the parapet wall for a few hours before being breached (Figure 4.4.2), while internal erosion of low-permeability cohesive soils is typically a long-term process. The related mechanism of piping, however could well have occurred if, for some reason, a void space existed through the embankment. Such void spaces often exist due to various reasons such as:

1. An animal burrowing through the embankment.
2. Decay of tree roots in the embankment (i.e., Figures 4.4.4 and 4.4.5) after the tree dies.
3. Laying of a pipe, cable, or culvert through the embankment, especially if done without care or without the use of bulkheads to prevent seepage of water at the structure-soil interface.

Though many trees were present on the embankment (Figures 4.4.4), their roots appeared to be quite thin and short (Figures 4.4.5), and thus unlikely to reach across the entire embankment width. Piping due to decayed tree roots is therefore unlikely to have been a cause of embankment failure, but the possibility cannot be entirely neglected. As such, the inspection of the entire embankment for the possibility of decayed tree roots (often indicated by dead trees or stumps), along with the removal and backfill of these roots, is an action item which the entity responsible for embankment maintenance should pursue (USACE, 2000).

4.4.3 Feasibility of displacement as a cause of failure

Landward displacement of an embankment due to the shear strength of the foundation not being able to resist the hydrostatic force acting on the water-side slope of the embankment is another oft-cited cause of embankment failure during floods. Figure 4.4.5 shows the dissimilar soils constituting the embankment and its foundation. However, there was no evidence of the levee being displaced as a whole. Furthermore, the gradual nature of overtopping followed by scour as reported by witnesses to the event, does not fit the sudden failure expected with displacement. Finally, the concrete bulkhead wall, which did not fail, resisted most of the hydrostatic head of the flood, leaving less than 1 m of head to act on the earthen embankment itself. Since the hydrostatic head acting on the embankment was small, since no evidence of embankment displacement was seen, and since displacement does not fit the eyewitness accounts of the event, displacement is unlikely to have been the cause of embankment failure.

4.4.4 Feasibility of bank erosion as a cause of failure

From the accounts of canal-dwellers and witnesses to the event, it is understood that neither the landside nor the water-side of the canal embankment at the breach site had been armored. Figure 2 shows a schematic transverse cross-section of the embankment along the breached reach. The masonry parapet atop the concrete bulkhead wall was lower than the earthen canal embankment crest. Within the breach section, the parapet wall had been even lower than it is on either side of the breach section (Figures 4.4.6 and 4.4.7). Due to this depression in the parapet wall height, one failure mechanism considered was the possibility that energetic canal flow along the unarmored waterside slope of the embankment above the parapet wall could have eroded the embankment, even without the water level rising high enough to overtop the original crest. If this erosion had progressed landward through to the landside slope of the embankment, overtopping would then have occurred, followed by failure of the entire embankment. This erosion could have been exacerbated by the location of a highway bridge pier in the West Drainage Canal adjacent to the breach site (Figure 4.4.8), as the pier could have caused acceleration of flow in its immediate vicinity.

To consider the feasibility of this failure mechanism, an erosion analysis of the waterside slope was carried out, as outlined in Simon et al (2000). Stream power is expressed by Equation (4.1)

$$\tau = \rho g R S \tag{4.1}$$

where τ is the average shear stress acting on a channel bank, ρ is the density of water, R is the hydraulic radius of the channel, and S is the friction slope. Assuming a wide channel, R reduces to the channel depth h, which is approximately 6 m when the canal is operating at its design capacity of 300 m^3/s (Deltares, 2013). The friction slope of the West Drainage Canal between the Manggarai and Karet gates during flood flow capacity is approximately 0.0004 m/m (Deltares, 2013). The resulting average shear stress exerted by the flow on the channel bed and bank during flood is thus about 24 Pa.

The embankment consisted of cohesive fine soil (Attachments 4.4.1- 4.4.3), but the critical shear stress for erosion was not measured. The critical shear stress for cohesive soils can range from 0.1 Pa for erodible fine soils, to 50 Pa for resistant fine soils (Simon et al, 2000). In order to determine whether bank erosion is a possible failure mechanism, we assume the weakest end of this range, with a critical shear stress τ_c=0.1 Pa. The erodibility coefficient k of soils is given by Hanson & Simon (2001) and Arulanandan et al. (1980) as equation (4.2)

$$k = 1x10^{-7} \tau_c^{-0.5} \tag{4.2}$$

For erodible cohesive soil, the erodability coefficient is k=3.2x10^{-7} m^3/Ns. The lateral retreat E (in meters) of the embankment due to erosion over a period of time $\triangle t$ (in seconds) is then given by Equation (4.3)

$$E = k(\tau - \tau_c)\Delta t \tag{4.3}$$

Figure 3 shows that the water level in the canal rose over the parapet wall on January 17 at about 8 am, while the embankment failed at about 10 am, allowing the process of bank erosion only 2 hours to tear at the embankment. During these 2 hours, equation (3) results in a bank retreat distance of 5 cm. Since the bank crest was over 1 m wide in its non-eroded sections, it can be assumed it had a width much greater than 5 cm even in the eroded section. As such, bank erosion could not have eroded all the way through the crest in the time allowed. Furthermore, the actual soil's critical shear stress was likely greater than the assumed value of 0.1 Pa, so the actual amount of bank retreat was likely even less than 5 cm.

In order to account for the possibility that flow was locally accelerated along the bank due to the presence of the highway bridge pier in the canal nearby (possibly further aggravated by debris-damming on the upstream edge of the bridge pier, as shown in Figure 4.4.8), this analysis can be recast with a local friction slope twice or even three times the canal's average friction slope. Using a friction slope of S=0.0008 m/m (twice the canal's average value), the bank retreat distance becomes E=10 cm, and a slope of 0.0012 m/m (3 times the canal's average value), the bank retreat distance is E=16 cm. In either case, the amount of erosion is nowhere near enough to erode through the approximately 1 m wide embankment crest. Furthermore, it's unlikely such steep water surface slopes existed. Assuming a Manning's n for firm soil of n=0.025 (Arcement & Schneider, 1984) a slope of S=0.0012 results in a flow speed of 4.6 m/s, but such an energetic flow and its resulting turbulence in the canal is not apparent from video of the breach. Whether or not such accelerated flow existed, lateral bank erosion of the embankment's water-side slope is not a feasible mechanism of embankment failure during this event.

4.4.5 Feasibility of overtopping as a cause of failure

The same stream power analysis that was applied to determine the feasibility of bank erosion can be applied to overtopping-induced erosion, though the stream considered is not that in the canal channel, but rather the shallow flow overtopping the embankment crest. Once water level 1 of Figure 4.4.2 was reached, the overtopping flow ran down the landward slope of the embankment, over the railroad tracks, and into the city below. The landward slope of the embankment had a slope of approximately 2:1 (horizontal:vertical). Making the assumption of normal flow, the friction slope becomes S=0.5 for the overtopping flow. Assuming the initial overtopping surcharge was R=10 cm, Equations (1), (2), and (3) can be used to estimate the depth of scour likely due to overtopping. Since overtopping-induced scour reduces the embankment crest elevation, the hydraulic radius R (equivalent to flow depth) increases as the crest scours away (assuming that the water surface level remains constant). Because of this unsteady process, scour depth must be evaluated as a function of time.

Using a time step $\triangle t$=1 sec in Equation (3), Figure 4.4.9 shows the estimated lowering of the embankment crest during the first 2 hours of overtopping, for erodible (τ_c=0.1 Pa), moderate (τ_c=5 Pa), and resistant (τ_c=50 Pa) cohesive soils. For both erodible and moderate soils, 2 hours is more than long enough for overtopping to have scoured the embankment crest about 20 cm down to the level of the parapet wall, after which scour continued to erode the embankment and the railroad ballast below. Resistant soil would have taken somewhat longer to erode down to the level of the parapet wall, but would have eroded nonetheless.

Figure 4.4.10 shows the channel scoured out of the embankment, running from the concrete bulkhead wall to the railroad tracks, conveying flood flow into the city below. Figures 5 and 6 show flow overtopping the concrete bulkhead wall along the breach section. After the initial embankment crest overtopping and breach occurred at the downstream end of the breach section, flow overtopping the concrete wall in the upstream part of the breach section began to flow into the breach channel. Figures 5 and 6 show that in this upstream section of concrete wall overtopping, the earthen embankment crest is not overtopped, but flow along the embankment is causing the embankment crest to retreat landward due to bank erosion.

4.4.6 Reasons for local embankment overtopping

There are three possible causes for local overtopping of the embankment crest in this location:

1. A local drop in crest elevation.
2. A local increase in water level due to flow impinging on the in-channel bridge pier of Figure 4.4.8.
3. Scour at the soil-concrete interface of the bridge pier in the embankment shown in Figure 4.4.10 or the tower in Figure 4.4.5.

A local drop in the embankment crest was observed downstream of the breach, apparently centered on the in-embankment bridge pier of Figure 4.4.10. Here, the embankment crest was many 10's of centimeters lower than the embankment crest further downstream or upstream. Locals corroborated that before the flood, this local dip in elevation continued through the breach section. They also said that before the flood there was further reduction of the embankment crest height below the gap between the two highway bridges at the site (Figure 4.4.11), due to rainwater drainage from the bridges impinging on the embankment crest, though this could not be verified in our own observations.

The possibility of a local increase in water level at the breach site is analyzed by assuming the bridge pier of Figure 4.4.8 is dammed with debris enough to cause local stagnation of the flow there. Using the data of Deltares (2013) outlined for the bank erosion analysis above and assuming a Manning's n=0.025 (Arcement & Schneider, 1984), the mean flow speed in the canal during flood was approximately 2.6 m/s. Stagnation flow depth increase can be estimated from the conversion of flow kinetic energy to potential energy shown by Equation (4.4)

$$\rho g \Delta h = \frac{1}{2}\rho u^2 \qquad (4.4)$$

where $\triangle h$ is the flow depth increase due to flow stagnation and u is the mean flow speed in the unobstructed flow region. Stagnation of a 2.6 m/s flow gives a local water level increase of 30 cm. In reality, it would be difficult to dam the pier enough for such full stagnation to extend laterally all the way to the embankment crest, so if the bridge pier did have any effect on water level at the embankment crest it was not likely more than a few centimeters.

Finally, the existence of a tower and bridge pier on the embankment crest (Figures 4.4.5 and 4.4.10) suggests that scour could have begun due to seepage through the structure-soil interface even before crest overtopping, though it's not possible to determine whether the breach did in fact begin in this way. Since the downstream edge of the crest breach is the bridge pier itself, scour could have begun here, resulting in local overtopping, with the overtopping channel then widening upstream. This possibility requires the bridge pier to have extended through the entire width of the embankment crest, but such data from before the flood is not available. In order to protect the embankment from scour due to seepage along a structure like this, proper structure-embankment transitions must be constructed, so as not to give floodwaters a straight path through the embankment along the soil-structure interface (USACE, 2000). For pipes passing through the levee, USACE (2000) recommends waterside and landside bulkheads as well as placement of drainage fill of 45 cm annular thickness along the landward 1/3 of the pipe's length crossing through the levee. For other structures, proper transition from the structure to the earthen levee by means of wingwalls and armor (USACE, 2000) or floodwalls and sheetpile (USACE, 1989) is necessary.

4.4.7 Conclusions and recommendations

The West Drainage Canal embankment failed due to overtopping of the embankment crest followed by scour of its landside slope. Overtopping occurred because of either a local dip in the embankment crest elevation, or seepage through the embankment along the concrete-soil interface of a bridge pier or tower in the embankment. Also possible is that another bridge pier in the canal channel nearby caused a slight increase of the local water level.

Measures to avoid another embankment failure like this are:

1. Inspection of the entire embankment for local dips in crest elevation, and then raising the crest in each of these locations.
2. Inspection of the entire embankment for encroaching structures that might give floodwaters a straight path along which to seep through the embankment, followed by either removal of each structure followed by backfilling, or construction of a proper structure-embankment transition for each structure per USACE (1989) and USACE (2000). Dead tree roots and animal burrows extending through the embankment should be noted and backfilled as part of this action as well.

After the embankment crest elevation is normalized and encroaching structures are either removed or bulkheaded, armoring the embankment crest and landside slope is a supplemental measure of protection against embankment failure even if overtopping occurs.

Along with these structural measures, flood response is also essential. During times of critical water level, teams should be mobilized to continuously patrol the canal. In locations where overtopping or other failure appears to be a danger, these teams can lay sandbags before failure occurs. Then, after the water level in the canal recedes, proper repairs can be conducted. If inspection and response teams had been mobilized for this purpose in January 2013, they might have noticed the dip in crest elevation or the seepage along the bridge pier or tower before the breach occurred.

4.4.8 References

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4.4.9 Figures

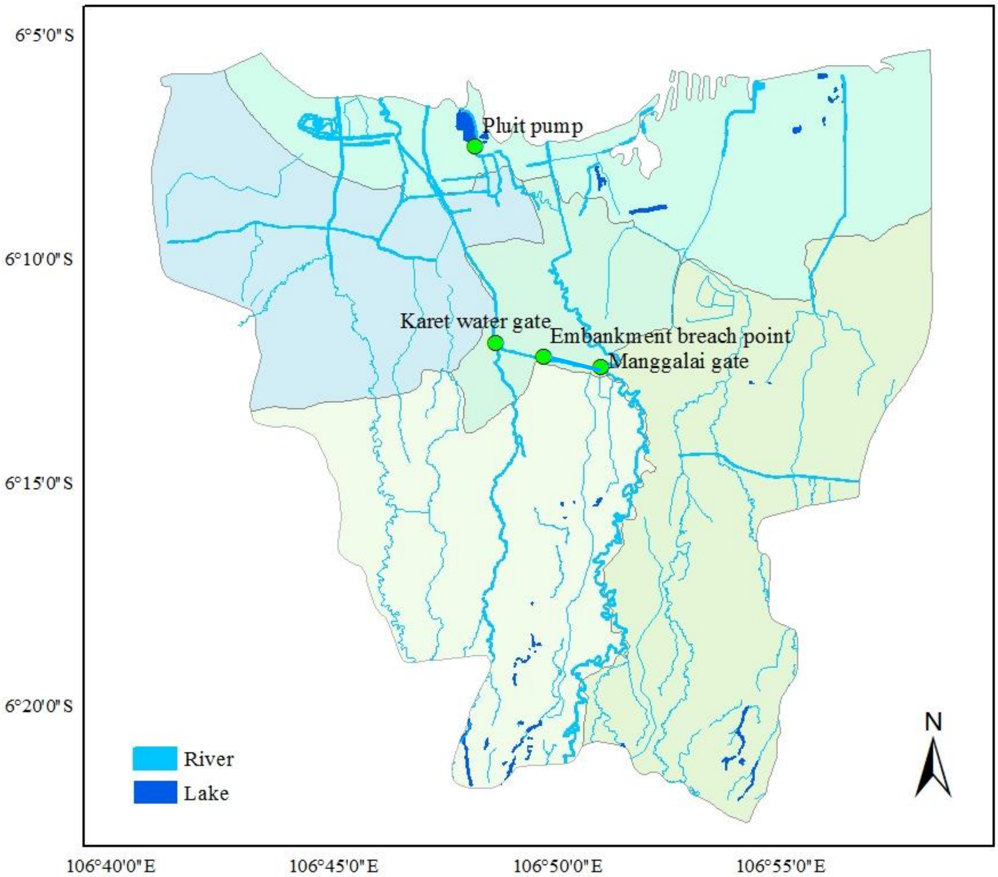


Figure 4.4.1. Map of Jakarta's rivers and canals.

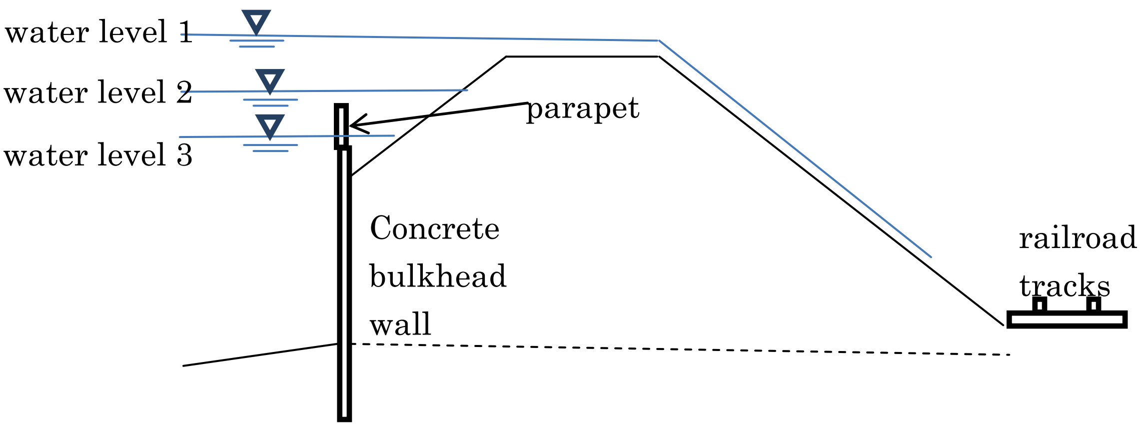


Figure 4.4.2. Schematic embankment transverse cross-section at breach location.

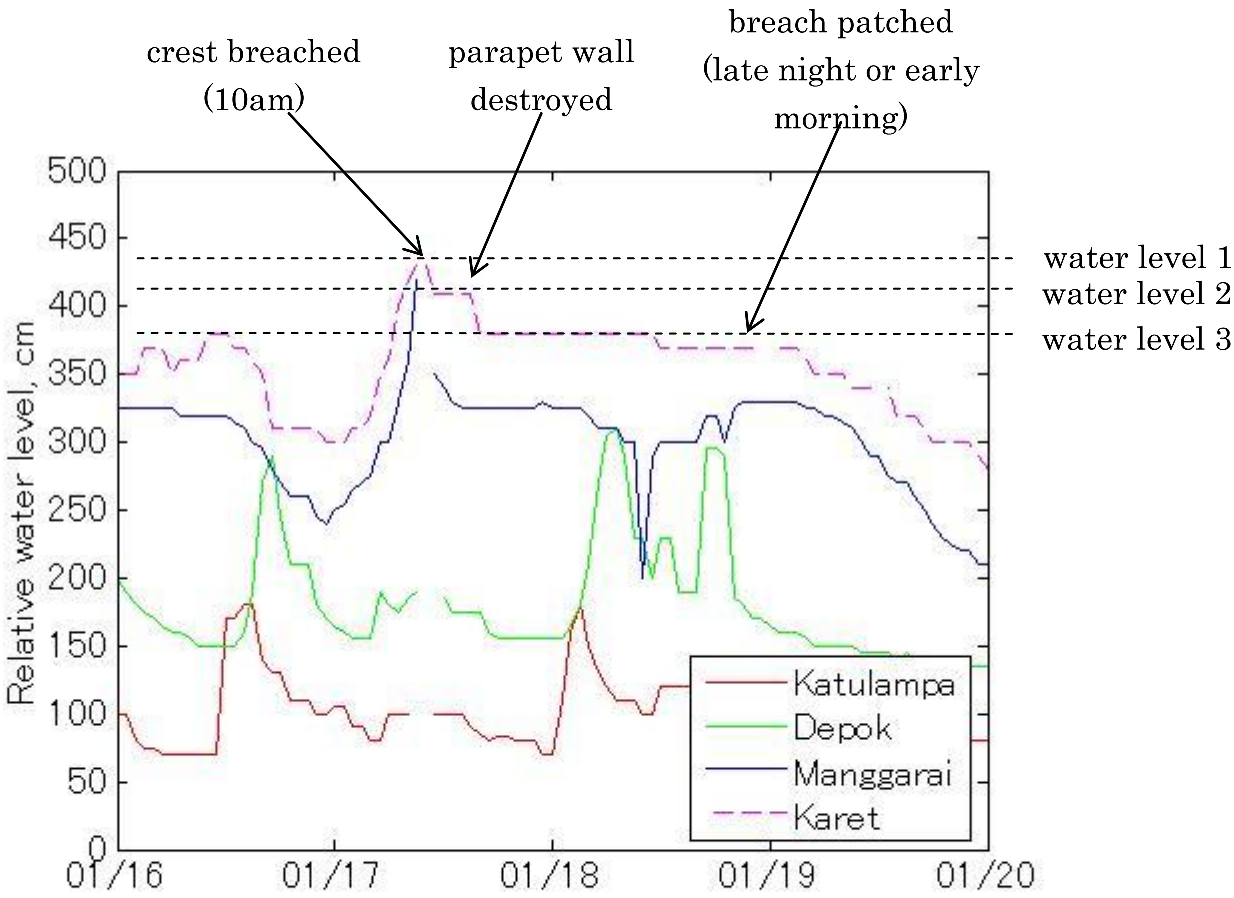


Figure 4.4.3. Water levels at four gates along the Ciliwuing River and West Drainage Canal system. Katulampa is furthest upstream, with about 3 hours flood travel time to Depok, then 9 hours travel time to Manggarai. Karet is slightly downstream of Manggarai. The canal breach site was between Manggarai and Karet, and was likely controlled by Karet.

Figure 4.4.4. Trees on the canal embankment crest at the upstream end of the breach location.

Figure 4.4.5. Video capture image from Jakarta News, showing overtopping of the concrete wall (at water level 3), tree roots in the canal embankment crest, and a tower foundation encroaching on the embankment.

Figure 4.4.6. Photo looking upstream by Hengki Eko Putra during canal failure. Note that the parapet wall on the upstream end of the breach drops in elevation through the breach site.

Figure 4.4.7. Downstream end of breach site, looking downstream (west). Note the remains of masonry atop the concrete wall between the sandbags and the parapet wall downstream. Note also that the parapet wall rises in elevation downstream of the breach site.

Figure 4.4.8. Highway bridge pier in West Drainage Canal beside breach, looking downstream.

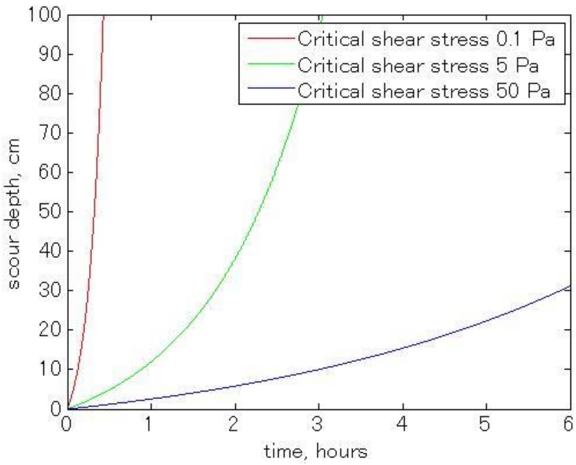


Figure 4.4.9. Depth of scour of embankment crest as a function of time for erodible, moderate, and resistant cohesive soils.

Figure 4.4.10. Photo by Hengki Eko Putra during canal failure. Note the bridge pier on the embankment at the downstream end (right-hand side) of the breach.

Figure 4.4.11. Gap between the two highway bridges above the embankment breach site.

SOIL MECHANICS LABORATORY
PROGRAM STUDY OF CIVIL ENGINEERING
BANDUNG INSTITUTE OF TECHNOLOGY

Form no. :
Issue/Revision :
Revision :

LAB TEST RESUME

Date : March 06th 2013

LOCATION : Jakarta

No.	Bore Hole	Depth (m)	Sample Type	Gs	Density γ_m kN/m³	Density γ_d kN/m³	n	Sr %	Wn %	Atterberg Limits LL %	Atterberg Limits PL %	Atterberg Limits IP %	Atterberg Limits Class	PSD Gravel %	PSD Sand %	PSD Silt %	PSD Clay %	PSD % finer by weight passing sleve # 200	Direct Shear c kN/m²	Direct Shear ϕ deg	UCS qu kN/m²	UCS cu kN/m²	UCS St	Coef. Of Permeability cm/sec	Consolidation eo	Consolidation Cc
1	1	-	DS	2.64	-	-	-	-	-	-	-	-	-	19	17	46	18	64	-	-	-	-	-	-	-	-
2	2	-	DS	2.72	-	-	-	-	-	-	-	-	-	7	15	49	29	78	-	-	-	-	-	-	-	-
TOTAL NO. OF TESTS				2	-					-				2					-		-			-	-	

Notes:

US = Undisturbed Sample
Gs = Specific gravity
γ_m = Bulk Density
γ_d = Dry Density
Wn = Moisture Content
LL = Liquid Limit
PL = Plastic Limit
IP = Plasticity Index
c = Cohesion
ϕ = Friction Angle
UU = Unconsolidated Undrained
CU = Consolidated Undrained
Cc = Compression Index
UCS = Unconfined Compression Strength
qu = Ultimate Stress
DS = Disturbed Sample

Checked by Engineer
Date : 06 March 2013
Name and Signature :
Faridansyah

Attachment 4.4.1. Summary of lab test results of soil from the Latuharhari embankment.

	SOIL MECHANICS LABORATORY PROGRAM STUDY OF CIVIL ENGINEERING BANDUNG INSTITUTE OF TECHNOLOGY	Form no. (No. formulir) Issue/Revision Revision (Revisi)	
	RESULT OF GRAIN SIZE ANALYSIS	Page 1 of 2	

Project : -

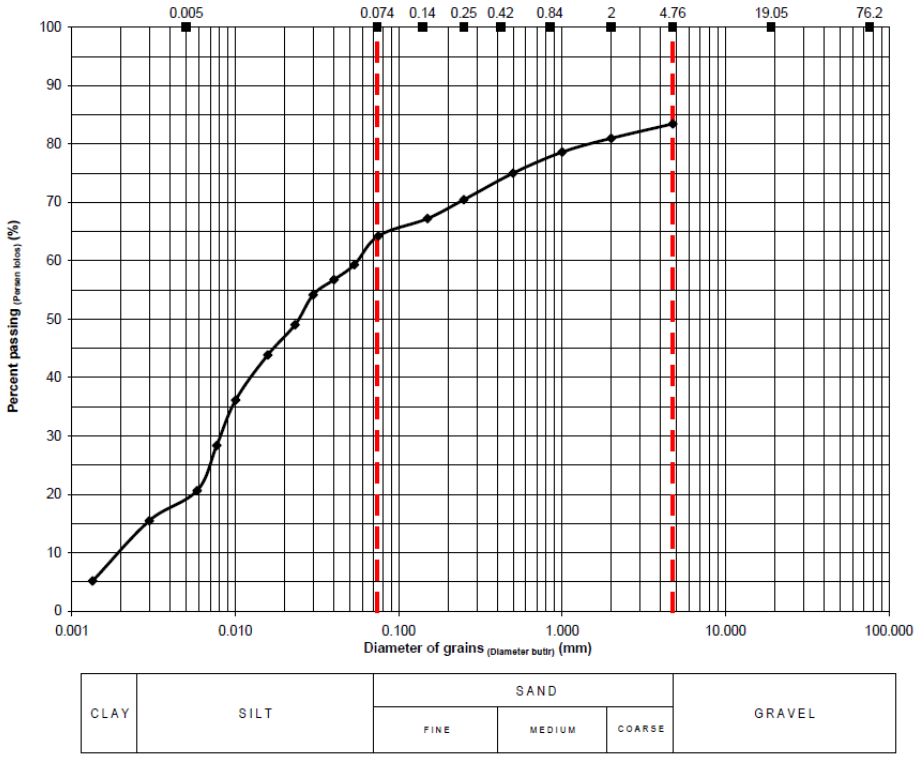
Type of sample : DS (Terganggu)

Sample no. : 1

Depth (m) : -

Location (Lokasi) : Jakarta

Result				
Gravel (Batu) (%)	:	19.01	D_{10}	:
Sand (Pasir) (%)	:	16.74	D_{30}	:
Silt (Lanau) (%)	:	46.18	D_{60}	:
Clay (Lempung) (%)	:	18.06	Cu	:
			Cz	:



Tested by Technician : Dadang T & Tatang S

Date : 06 March 2013

Attachment 4.4.2. Grain size distribution of soil sample 1 from the Latuharhari embankment.

	SOIL MECHANICS LABORATORY	Form no. (No. formulir)	
	PROGRAM STUDY OF CIVIL ENGINEERING	Issue/Revision	
	BANDUNG INSTITUTE OF TECHNOLOGY	Revision (Revisi)	
	RESULT OF GRAIN SIZE ANALYSIS	Page 1 of 2	

Project : -

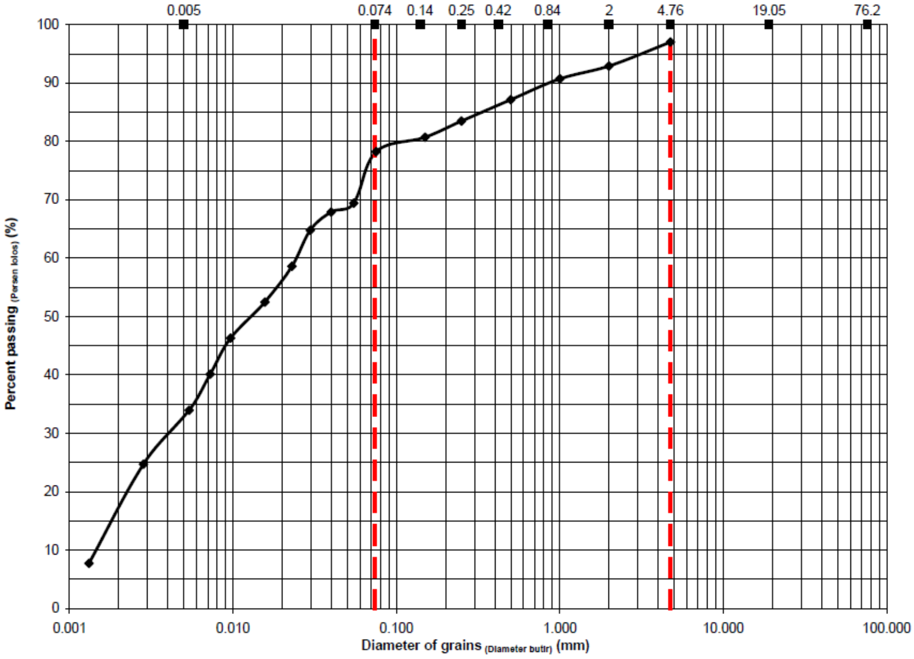
Type of sample : DS (Terganggu)

Sample no. : 2

Depth (m) : -

Location (Lokasi) : Jakarta

Result					
Gravel (Batu) (%)	:	7.10	D_{10}	:	
Sand (Pasir) (%)	:	14.66	D_{30}	:	
Silt (Lanau) (%)	:	48.93	D_{60}	:	
Clay (Lempung) (%)	:	29.31	Cu	:	
			Cz	:	



CLAY	SILT	SAND			GRAVEL
		FINE	MEDIUM	COARSE	

Tested by Technician : Dadang T & Tatang S

Date : 06 March 2013

Attachment 4.4.3. Grain size distribution of soil sample 2 from the Latuharhari embankment.

4.5 Trash

One likely culprit in the January 2013 flood of Jakarta was trash. As Figures 4.5.1-4.5.4 show, floating trash collects at hydraulic structures such as gates and bridge piers. Figure 1 shows the Mangalai (west drainage canal) gate, connecting the upper Mangalai River with the west drainage canal, the main pathway for water to flow around Jakarta's downtown and reach the ocean. Trash screens are raised in the photo, possible in an attempt to clear too large a jam of trash from the upstream edge of the gate. Floating trash that does not dive through the gate opening (Figure 4.5.2) is collected manually by a picker.

During a flood, it's possible that so much trash accumulates that the flow capacity of the Mangalai (west drainage canal) gate, and the similar Karet gate, are reduced. In fact, 3 of the 4 openings of the Karet gate (no photo available) were reported by Deltares to have been entirely clogged by trash during the January 2013 flood. If this indeed had been the case, it's possible that reduced flow capacity of the Karet gate caused backwater into the west drainage canal, and that this backwater resulted in a water level high enough to cause overtopping and failure of the west drainage canal embankment, which henceforth resulted in severe and unexpectedly rapid flooding of Jakarta's commercial center, and two ensuing deaths.

Likewise, reduction of flow capacity of the Mangalai (west drainage canal) gate due to clogging by trash could have caused backwater into the upper Ciliwung River, possibly resulting in overtopping of the Mangalai (Old Ciliwung River) gate, or a water level at this gate dangerously high enough to have prompted the operator to open the gate in order to relieve stress on the gate and prevent failure of the structure or of the canal embankments downstream.

Figure 4.5.3 shows trash accumulating at the entrance to Pluit sump. At this time, trash screens were closed. Assuming reasonable SOP, trash screens would be open during floods, so as not to cause backwater into the drainage canals. However, as Figure 4.5.4 shows, trash can accumulate on piers, and cause debris damming resulting in backwater upstream into the canal. Trash can also accumulate on the drop structure entering Pluit sump (Figure 4.5.5), also causing backwater into the canal.

Whether trash was the major culprit in last month's flooding cannot be stated, but it is certainly one of the players. However, the questions of why this problem exists, and what can be done about it, are more difficult to answer. Local government agencies state that the problem is one of education, as poor canalside and riverside residents find disposing of their trash in the city's waterways easier than hauling the trash to a government-specified trash collection sites. Through education, residents can learn that the very trash they carelessly throw into the canals is responsible for the floods that soil their homes and inconvenience them. In addition to being lazy, canalside residents may have come to view disposal of their trash in waterways as a social norm, meaning that they who haul their trash to proper collection sites are not conforming to the norm. In order to conform, most residents throw their trash into waterways. Further complicating the situation is that most of these canalside residents are illegal squatters, and the communities are illegal shantytowns, without government services. It's a conundrum for the government as to whether it should provide services such as trash collection to areas that are developed illegally. The crowding of these areas even makes trash collection trucks unable to access these neighborhoods.

However, when interviewing local community organizations, the root of the trash problem took a different light. Communities claim that the reason they dispose of trash in waterways is because the government doesn't collect trash. Some communities have organized their own trash-collection services, paying nominal fees to local haulers and separators, who separate disposables from recyclables and then haul the trash to government collection sites. These communities claim that the government doesn't collect trash close enough to their communities nor frequently enough to be convenient for poor people to use. They suggest trash collection by barge as one way to overcome the difficulty of accessing crowded shantytowns.

Though the IRIDeS team could not verify whether the government's or the communities' viewpoints are closer to the truth, the importance of preventing trash from reducing the capacity of the city's drainage system is beyond debate. If the trash loading to the system cannot be reduced via education or social changes, then an engineering change to the system is necessary, in removing all hydraulic structures in the floodways and giving floodwaters a clear path to the sea. However, this would mean removing the gates which allow flow to local canals during dry periods when those canals would otherwise run dry. Allowing local canals to run dry could cause environmental distress along those canals, as surrounding areas would be left with no drains for wastewater (unless proper sewer systems are installed).

Figure 4.5.1. Floating trash at the entrance to the Mangalai (west drainage canal) lift gates. These gates are always open, as the west drainage canal is the main pathway for water from the upper Ciliwung River to reach the ocean.

Figure 4.5.2. Floating trash accumulating at the Mangalai (west drainage canal) gate, where flow dives into the gate opening.

Figure 4.5.3. Trash screens at the entrance to Pluit sump. Were these screens raised during the January 2013 flood, to prevent backwater due to debris damming of the screens? Is this SOP?

Figure 4.5.4. Trash causing debris damming of the bridge pier beside the site of the west drainage canal embankment breach.

Figure 4.5.5. Drop structure entering Pluit sump.

4.6 Dredging

One possible cause of repeated flooding in Jakarta, and especially the January 2013 flood, is lack of regular dredging of the city's drainage system. The problem of sedimentation in Jakarta's canals has not gone unrecognized, and dredging has once again come to the forefront of the city's priorities. Currently, a $160 million World Bank sponsored project called the Jakarta Emergency Dredging Initiative (JEDI) is underway. JEDI aims to dredge all of Jakarta's canals.

Jakarta's drainage system works such that water flowing toward the city from the upstream Ciliwung River basin is diverted around the city by the west drainage canal, which has a capacity of 390 m^3/s when dredged fully. This water enters the ocean via gravity. Rainfall which falls within the city itself, and water which leaks from upstream (including the west canal) into the city, is funneled via small local canals into the Pluit sump, from which it is pumped upward to the ocean. As such, sedimentation of the west canal reduces the canal's capacity to carry flood flows, which can result in flooding of the city if either the canal's embankment is overtopped, or if the Mangalai (Old Ciliwung) or Karet lift gates, which separate the west canal from the city, are opened to reduce the water level in the west canal.

Sedimentation in Pluit sump affects flooding in the city by elevating the water level in the sump. The backwater due to this can cause water levels in the local canals feeding Pluit to increase, flooding low-lying urban areas of the city. Elevated water levels in Pluit sump also submerged one of the sump's outlet pump stations, putting the drainage pumps out of service during the January 2013 flood (of the other two pump stations, one was out of service for maintenance, and the other failed when electricity failed and backup fuel supplies were flooded).

Previous to 1995, the Pluit sump had been dredged regularly by a Dutch consultant, but since then the sump had not been dredged until the JEDI project began. In 1995 the bed of the sump had been 10 m below the adjacent roadway surface, but it is currently only 2 m below the road. Backhoes are used to scoop material from the sump and the canals leading into it. Dredge spoils are then transported off-site by trucks. Figures 4.6.1 and 4.6.2 illustrate the current situation of Pluit sump and the canal entering it.

Sedimentation and trash accumulation in the Old Ciliwung River and local drainage canals inside the city is also problematic (Figure 4.6.3), as elevated water levels in these canals prevents drainage of rainfall to Pluit sump, causing flooding of surrounding areas. The specified capacity of the Old Ciliwung River is 50 m^3/s, but this small flow rate is further reduced due to sedimentation, and is thus one of the likely culprits in the January 2013 flooding of Jakarta's governmental center.

Figure 4.6.1. Dredges operating at the entrance to and inside Pluit sump.

Figure 4.6.2. Sedimentation and trash in the canal leading into Pluit sump.

Figure 4.6.3. Sedimentation and trash “islands” in the Old Ciliwung River just below the closed diversion gate. The presence of so much trash just downstream of the closed gate indicates that the gate may have been either opened or overtopped recently.

4.7 Illegal development in the floodplain

Illegal development in river channels, canals and floodplains such as construction of houses (Figure 4.7.1) in these areas may be contributing to reduction of the flood-carrying capacity of these river channels and canals and the overall drainage capacity of Jakarta city. Jakarta's drainage system should be evaluated using a hydrologic/hydraulic model considering not only sediment and trash deposition on the river bed and clogging gates, but also considering the effect of illegally constructed structures on flow capacity in the river channels. In addition, this illegally inhabited zone is easily inundated and houses built in the zone are easily flushed away during floods. This is an important social issue to be considered for future flood management and Jakarta city development plans.

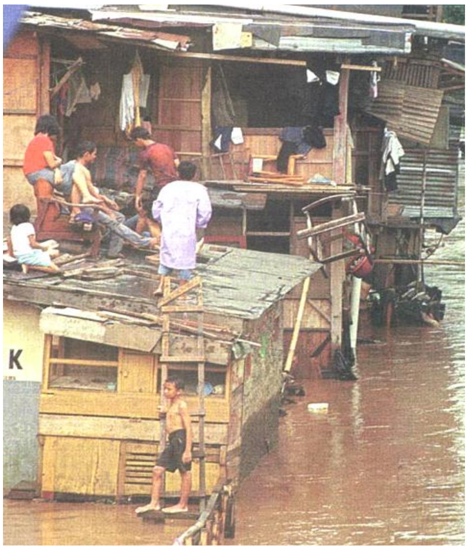


Figure 4.7.1. Illegally constructed houses in Jakarta's river channels and drainage canals.

4.8 Pump failure

One of the causes of the January 2013 flood in northern Jakarta was the failure of the pumps at Pluit. All rain water that falls in northern Jakarta between the west and east drainage canals and the ocean, is transported via local canals to Pluit, the sump of the system. From Pluit, it is lifted up into the ocean via a large pump station. The Pluit sump was designed as a broad, low-lying area for water storage, in order to keep a low water level to accept water from the city's canals during operation of the pumps to evacuate water to the ocean. The storage capacity of this sump has been greatly reduced due to sedimentation of the bed of the sump (from 10 m depth originally to the current 2 m depth) and encroachment of illegal housing into the sump (reducing its effective storage area from 80 Ha to 60 Ha).

The Pluit pump complex consists of 3 pump houses. The central pump house has a capacity of 16 tons/s, the west pump house can move 13 tons/s, and the east pump house can evacuate 18 tons/s. During the January 2013 flood, the east pump house had been out of service for maintenance. The central pump house, which is reported to be heavily subsided, was quickly flooded, rendering its pumps useless. The west pump house functioned until its power supply was interrupted when the power station supplying it was flooded and its own backup fuel supply was inundated. As such, water could not be evacuated from Pluit sump, nor from the canals of north Jakarta leading to the sump, until power was restored to the west pump house and the pumps from the east pump house were put back into service. The central pump house was not again useful until the other pump houses lowered the water level enough to bring the central pump house's electrical equipment back into the dry.

An obvious question is why the Pluit pumps failed so quickly during this flood, while the rainfall was not nearly as intense as in 2007. The combination of sedimentation inside the Pluit sump and encroachment of shantytowns has reduced the storage capacity of the sump, so that water level quickly rises higher than historical water levels. Furthermore, the breaching of the west drainage canal embankment and the possible overtopping or opening of the Mangalai (Old Ciliwung) gate allowed water from the upper Ciliwung to flow to Pluit, whereas under normal conditions such water flows by gravity through the west drainage canal to the sea. This may have subjected the Pluit sump to a greater inflow volume than it experienced in 2007, even though rainfall in north Jakarta was not as intense as it had been in 2007.

5. Measures currently underway and planned for flood mitigation in Jakarta

Having initially been a frequently flooded river delta, the system of canals that provide the city with flood control dates back hundreds of year, to the Dutch colonial days. As the city expanded, the large west and east drainage canal scheme, to divert most of the Ciliwung River water around the city core, were formulated almost one century ago. The west drainage currently forms the main route for the upper Ciliwung River to enter the sea, while construction of the east drainage canal has not yet been completed, due to political difficulties acquiring the necessary land. Once construction of the east canal and its connection to the upper Ciliwung River and the west drainage canal is complete, the design flood conveyance capacity of Jakarta's drainage system will increase, but the new drain will still be affected by the same problems that plague the west drainage canal: illegal riverbank development reducing capacity, trash clogging hydraulic structures, sediment deposition and neglected dredging, and land subsidence. Furthermore, operation of the east drainage canal will help divert upstream flood flows around the city, but won't affect the city's ability to evacuate local rainfall, which occurs via local canals and the Pluit pumps.

Thanks to a loan from the World Bank in what is termed the Jakarta Emergency Dredging Initiative (JEDI), initiated after the 2007 flood, Jakarta's entire drainage system is currently undergoing dredging, which had not been undertaken in 15 years. However, due to illegal floodplain development, construction equipment used for dredging cannot reach the riverside in many areas.

In addition to dredging, the regional government is trying to relocate squatters from their riverside shantytowns and from Pluit sump, so as to reclaim these areas for the purpose of water storage. To do so, the governor is constructing low-cost housing to relocate these people to, and also providing them with low-cost city bus passes so that they can commute to their jobs. However, relocating squatters is a difficult task, as some of the officers tasked with relocation accept bribes by the squatters to not force them out. Furthermore, many squatters feel that living along the riverbank is more convenient for them than moving to city-supplied housing, from which they'd have to commute long distances to their work, so even after being relocated many of them return to the floodplain. Finally, many squatters have been living in the floodplain for such a long time now that they have invested in their homes and formed communities, both of which they are reluctant to leave.

Work is currently progressing on increasing the pumping capacity of Pluit, which is currently 30 tons/s when all pumps are operational. Pluit's east pump station (pumping capacity abougt 15 tons/s), which had been out of service for repairs during the January 2013 flood, will be back online soon. Furthermore, JICA loans are financing the construction of two new pump stations at the ends of nearby canals in Marina and Ancol. These will reduce the load on the Pluit system by giving water other exits from Jakarta's polders, and will bring the total pumping capacity from 30 tons/s to 79 tons/s.

Flood relief wells are also currently being constructed in Jakarta. Conceptually, these wells are to capture water during floods and let the water percolate into the ground. As Jakarta's groundwater has subsided due to over-extraction, the upper ground surface is unsaturated. The current governor of Jakarta has proposed requiring landowners to build these recharge wells, so that the total number of well would be in the thousands. Hydrologically, this strategy could help reduce the runoff coefficient that has so quickly increased due to rapid urbanization and paving. It could also help replenish the city's groundwater. However, the effectiveness of these wells as a flood control measure depends on the permeability of the soil. In areas with impermeably clay soil, the wells might not be effective at reducing flood water levels. Furthermore, they are likely to require maintenance so as not to fill in with sediment and trash.

Another idea proposed for reducing flood risk of Jakarta and under serious consideration is a deep tunnel for stormwater storage. If maintained properly, such a tunnel would help reduce peak flood flows and water levels. However, intakes to the tunnel would face the problem of clogging with trash, reducing the amount of flow into the tunnel. Likewise upon pumping out, trash that enters the tunnel could clog exit pumps, and would have to be cleared manually, which might not be easily accomplished on a large scale underground.

In addition to underground storage, surface storage measures have been proposed, both in the city and upstream. Surface storage in the city has been difficult to realize because of the tendency of squatters to occupy such areas (as is already the case in Pluit and along the Ciliwung River and west drainage canal), thereby reducing the storage capacity of these areas. Surface storage further upstream will help reduce the peak upstream flood flow, but such reservoirs must be maintained so as not to sediment in. However, such measures will not reduce the city's flood risk due to local rainfall, which is evacuated via local canals and the pumps at Pluit.

6. Modeling plan - a physically based distributed rainfall runoff model and flood inundation model

For the analysis of the Jakarta flood, a physically based flood inundation model considering the effect of building in dense urban areas (Farid et al., 2012) will be employed in this study. The framework for the methodology is shown in Figure 6.1. Generally, data sets (rainfall, land cover, DEM, soil type) are used for hydrological processes in a tank model, resulting in surface runoff and subsurface flow that determine overland flow. River cross sections and upstream discharge are input for a channel model connected with an overland flow model by using flow exchange.

6.1. Overland Flow Model

The governing equation for the shallow water equation consist of the continuity equation shown in Eq. (6.1) and the momentum equation in the x direction shown in Eq. (6.2) and the y direction shown in Eq. (6.3):

$$\frac{\partial h}{\partial t} = \frac{\partial uh}{\partial x} + v\frac{\partial vh}{\partial y} = q_0 \tag{6.1}$$

$$\frac{\partial u}{\partial t} + u\frac{\partial u}{\partial x} + v\frac{\partial u}{\partial y} + g\frac{\partial(h+z)}{\partial x} = -gS_{fx} \tag{6.2}$$

$$\frac{\partial v}{\partial t} + u\frac{\partial v}{\partial x} + v\frac{\partial v}{\partial y} + g\frac{\partial(h+z)}{\partial y} = -gS_{fy} \tag{6.3}$$

where u and v are velocities on their corresponding axes, h is water depth, q_o is an outsource term such as rainfall, infiltration, etc., and S_f is the friction slope calculated with Manning roughness n using Eqs. (6.4) and (6.5):

$$S_{fx} = n^2u(u^2+v^2)^{1/2}/h^{4/3} \tag{6.4}$$

$$S_{fy} = n^2v(u^2+v^2)^{1/2}/h^{4/3} \tag{6.5}$$

6.2. Channel Model

A channel model was developed using the same governing equation as the overland flow model under a 1D assumption. A continuity equation for 1D flow is given in Eq. (6.6) and a momentum equation is given in Eq. (6.7):

$$\frac{\partial A}{\partial t} + \frac{\partial Q}{\partial x} = q_l \tag{6.6}$$

$$\frac{\partial Q}{\partial t} + \frac{\partial(uQ)}{\partial x} = gA\frac{\partial(h+z)}{\partial x} - \frac{gn^2|Q|Q}{R^{4/3}A} \tag{6.7}$$

where A is the area of the cross-section, Q is discharge, q_l is lateral inflow or outflow distributed along the x-axis of the watercourse, u is velocity, and h is water depth.

6.3. Flow Exchange Model

The 1D and 2D flows are connected by flow exchange. Basically, overflow can occur in either direction from the surface to the river or vice versa. The water level above datum in the river and over the land surface governs the mechanism of flow exchange, as shown in Figure 6.2.

Overflow is calculated under two conditions – complete overflow ($h_2/h_1 < 2/3$) as described in Eq. (6.8) and submerged overflow ($h_2/h_1 \geq 2/3$) as described in Eq. (6.9) – where q is overflow per unit width and h_1 and h_2 are water levels on either side above the levee (Dutta et al., 2007):

$$q = 0.35h_1\sqrt{2gh_1} \tag{6.8}$$

$$q = 0.91h_2\sqrt{2g(h_1 - h_2)} \tag{6.9}$$

6.4. Tank Model

The nearly calibration-free (NCF) tank model is coupled with the outsource term in Eq. (6.1) to accommodate the hydrology parameter, which covers infiltration, precipitation, and interception. Interception is calculated by using Eq. (6.10):

$$P = KEt_D + S \tag{6.10}$$

where P is the amount of precipitation intercepted for one period of rain, KE is the vegetation interception rate during rainfall, t_D is rainfall duration, and canopy storage is symbolized by S. Infiltration and subsurface flow calculation are applied to each grid point. The infiltration rate shown in Eqs. (6.11) and (6.12) is determined by soil hydraulic conductivity and water content in the top tank. The relation among precipitation, hydraulic conductivity, and the infiltration rate is governed by the amount of precipitation and hydraulic conductivity. An infiltration coefficient is added to accommodate recharge in urban zones:

$$q_{inf} = c_{density}(1 - \lambda_i)q_{re} \tag{6.11}$$

$$q_{re} > k^*_{h_i} \rightarrow q_{inf} = c_{density}k^*_{h_i}; \quad \lambda_i = \frac{H_i}{H_{i_{max}}} \tag{6.12}$$

where k^*_{hi} is the saturated hydraulic conductivity, q_{re} is effective rainfall, λ is water content in the top tank, H_i is water depth in the tank, H_{imax} is tank height, and $c_{density}$ is the density rate of the impervious area. The subsurface flow is calculated by using the Darcy (positive) approach shown in Eq. (6.13):

$$q_i = ck^*_{h_i}I\lambda_i \tag{6.13}$$

where c is the interflow coefficient and I is the surface slope.

6.5. Influence of Building

The application of the building sharing rate, shown in Figure 6.3, for accommodating the influence of buildings is included in the modified momentum equation for overland flow shown in Eqs. (6.14), (6.15), and (6.16):

$$\frac{\partial u}{\partial t} = u\frac{\partial u}{\partial x} + v\frac{\partial u}{\partial y} = -g\frac{\partial(h+z)}{\partial x} - \frac{\lambda}{2\sqrt{\overline{A_i}}}C_D u^2 - (1-\lambda)gS_{fx} \tag{6.14}$$

$$\frac{\partial v}{\partial t} = u\frac{\partial v}{\partial x} + v\frac{\partial v}{\partial y} = -g\frac{\partial(h+z)}{\partial y} - \frac{\lambda}{2\sqrt{\overline{A_i}}}C_D v^2 - (1-\lambda)gS_{fy} \tag{6.15}$$

$$A = \sum_{i=1}^{N} A_i\,; \quad A = N\overline{A_i}; \quad \overline{A_i} = \frac{A}{N}; \quad \lambda = \frac{A}{\Delta x \Delta y} \tag{6.16}$$

where A is the total area of buildings in a grid cell, N is the number of building in a grid cell, C_D is a drag coefficient, A_i is the average area of a homogenized grid cell, Δx is grid size in the x direction, Δy is grid size in the y direction, and λ is the building sharing rate.

6.6. Application results

The model was applied to the Cilliwung River basin for the 2002 flood event, 28 January – 2 February 2002 (Farid et al., 2012). Rainfall input is distributed spatially generated from observation data. Water level comparison and discharge comparison at Manggarai station are shown in Figure 6.4. It is shown that the water level does not instantaneously respond to rainfall. Similar behavior is also observed in discharge. These comparisons suggest that river discharge is over capacity. The slow increase in water level and in the hydrograph rising curve indicates that overflow and inundation occur. Inundation acts as storage, thus reducing the response to rainfall. Details of the model's structure and simulation conditions can be found in Farid et al. (2012).

6.7. Future modeling plan

The model used in Farid et al. (2012) will be the basic model for this research and will be applied to the 2013 flood. Also, this model will be extended for application to the whole of Jakarta city. The modeling plan in this study is as follows;

1st year (- 31/03/2014)

1. The model will be applied to the floods of 2002, 2007 and 2013.
2. The model will be improved and extended to the other 12 river basinsthroughout Jakarta city, and then applied to the floods of 2002, 2007 and 2013 again.
3. The model will be used to evaluate land use/cover change and land subsidence impacts on Jakarta flooding.
4. Other factors causing flooding in Jakarta, such as sediment and trash deposition on the river bed and in gates will be quantitatively evaluated using the model.
5. The model will be used to evaluate several countermeasures quantitatively.

2nd year (-31/03/2015)

6. The model will be improved as an operational model which will use real-time radar rainfall information as input to forecast floods.
7. The model will be improved as an initial disaster assessment model to be applied throughout the world, especially in developing countries.

The operational model should be constructed based on the concept of real time forecasting using radar rainfall information. The results of the model should be delivered to residents of hazard areas through an online network in real time. This model requires a fast computational scheme and a data assimilation system using observed data from rain gauges and water level recorders.

The initial disaster assessment model is a new tool for evaluation of flood damage which will be applied throughout the world using only global datasets and satellite driven datasets. After a flood disaster happened somewhere in the world, this model will provide quick first simulation results such as rough flood inundation maps to the flood damaged region using global datasets, and this model will predict the real time and near future situation of the flood. This model should be developed for not only the Jakarta flood but also for other future floods throughout the world, especially in developing countries. This model will be useful for detecting and understanding initial flood damage and for directing local governments to appropriately and quickly respond to flooding.

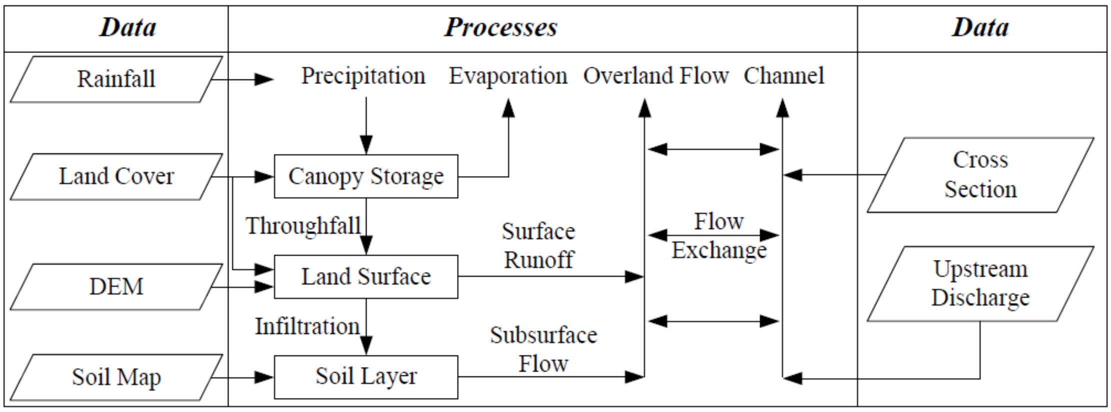


Figure 6.1. Model framework (Farid et al., 2012)

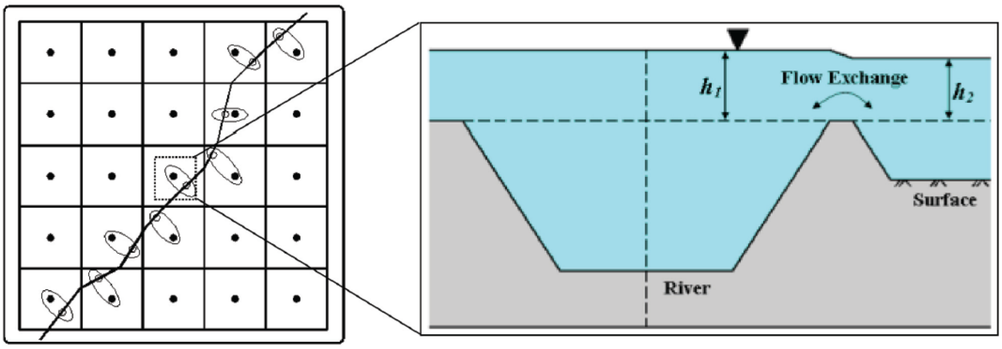


Figure 6.2. Flow exchange (Farid et al., 2012)

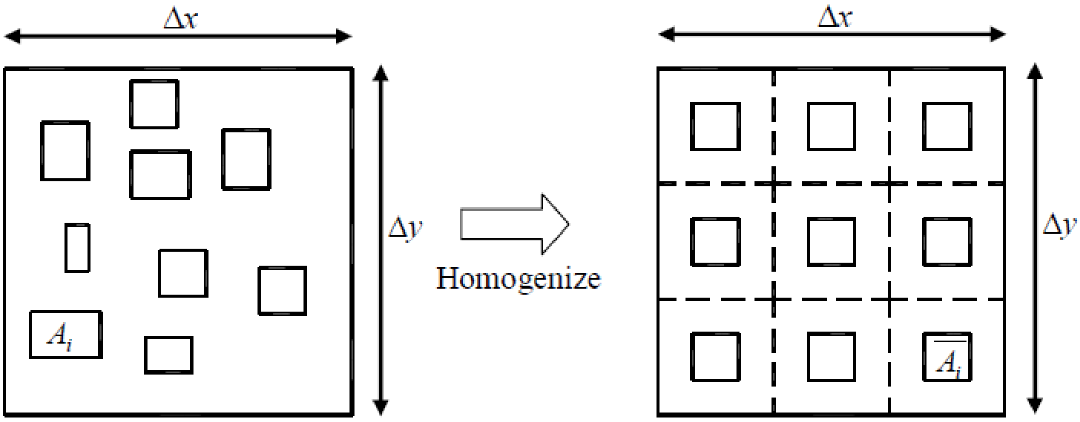


Figure 6.3. Sharing rate of building (Farid et al., 2012)

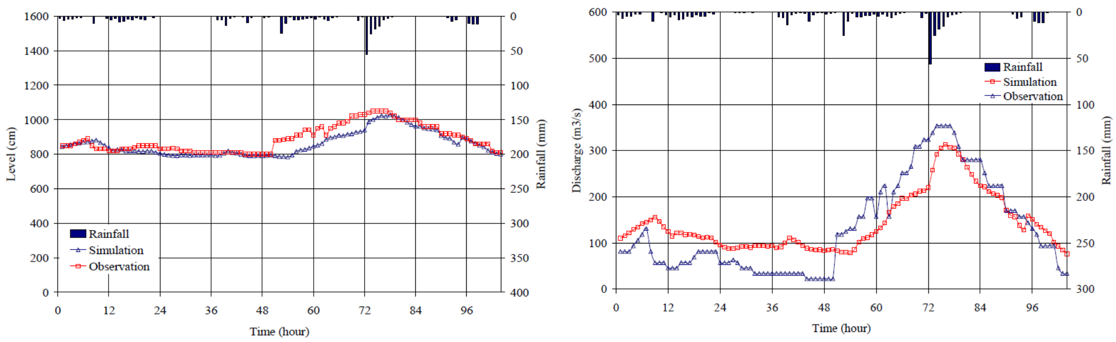


Figure 6.4. Model result comparisons: water level (Left) and discharge (Right) (Farid et al., 2012)

6.8. References

D. Dutta, A. Alam, K. Umeda, M. Hayashi, and S. Hironaka, “A two-dimensional hydrodynamic model for flood inundation simulation: A case study in the lower Mekong river basin,” Hydrol. Processes, Vol.21, pp. 1223-1237, 2007.

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7. Effects of and countermeasures against flooding in Jakarta

7.1. Evacuation and public response

7.1.1. Meetings and survey plan

Critical questions exist as to why communities behave toward disaster as they do. Why do people build illegally in floodplains? Why do people dispose of trash in rivers when they know this behavior will lead to exacerbation of flooding? Why do people stay at home despite evacuation warnings?

Summary of the meeting at Ministry of Science LIPI, 11 Feb 2013
Meeting participants
IRIDeS team (5 person)
LIPI team (11 person)
PusKris UI – Crisis Center, Indonesian University (2 person)
About the participants:
1. Community Preparedness (COMPRESS) – LIPI
COMPRESS – LIPI is a ministry that focuses on disaster education especially for school children. They mostly work on earthquake and tsunami preparedness and have much experience with assisting the government (BNPB) on developing national guidelines for tsunami preparedness and education.
2. The Ciliwung River community is an organization that assists people who live along the Ciliwung River to improve the river environment on their own, especially to improve the garbage problem.
3. The Crisis Center Indonesian University is a research center focused on the assessment of psychological aspects before, during and after disaster, which relates to risk perception, social behavior and post traumatic stress disorder.

About the meeting:
The topics discussed in the meeting were split into two major issues; (1) people's behavior related to the habit of dumping trash into the river and (2) a questionnaire survey about evacuation behavior.
1. About the behavior related to dumping trash in the river, community representatives said that it was due to the absence of temporary garbage collection points. Even when such collections places were available, the locations were far away from the dense population nearby the riverbank.
2. The proliferation of poor households along the Ciliwung River is mostly cause by the tendency of 'following relatives' who already live there. Most of these squatters have no fixed income, so there is no option for them to stay in Jakarta except to live together on the Ciliwung riverbank.
3. Even though they were affected by flooding every year; there was a 'natural' resilience due to the lack of options available to poor households along the Ciliwung River. 'Yes we have floods one month a year, but we still have the other 11 months a year to live normallhy.'
4. About evacuation behavior; people slightly misunderstood the word 'evacuation'. The community representation thought that 'evacuation' means relocation from the flooded area (riverbanks). Therefore, when the question why some parts of community were not evacuated during the flood, they said the main reason is because their economic activities are nearby their house (i.e. temporary shop or garbage collection from the river).
5. About the questionnaire survey; since preliminary information about the

heterogeneity of the society as well as demographic data along the Ciliwung Riverbank are not available, this site visit survey is suggested to be used as the way to 'sense the problem,' so a more detailed questionnaire can be designed for further research.

6. 'Sensing the problem' will be related to the following items on influencing the evacuation behavior:

a. Attribute (personal): experience, hometown (native or not) etc.

b. Dynamic: income, figure effect (leader of community) etc.

7. If the above considerations can be identified, there will be another option to distribute and collect the questionnaire through government officials in the smallest administration area.

Figure7.1.1.1. Group photo after meeting in LIPI, Indonesia

Survey of the affected community, 12/2, 2013

Location1: Cililitan Sub-district

Key person: Agus Salim (+6281 2964 1090)

1. About the early warning: this community receives warning from the head of the sub-district (kelurahan)
2. The head of the sub-district issues the warning if the water level at the water gate in the upstream area (Katulampa) is in the stage of 'alert 3.' This stage means the water will be around 1 m above the normal height in Cililitan area.
3. The warning is also issued through the loud speaker at small mosques situated inside the community.
4. During the flood in January, around 50% of the household in this community did not evacuate due fear for security of their homes.
5. For those who evacuated, they stayed in small mosques and their family's houses. There are no designated/official evacuation sites.

6. About the public health issue after the flood, the community expects the hospital can do some of the eradication of mosquito larvae. However, the hospital declines this request because it only carries out mosquito eradication after cases of mosquito-borne diseases (i.e., dengue) are reported.
7. Another issue is miscommunication between the government and community when making plans for flood control, i.e. during the last three formal meetings, the community has requested the government to normalize the river by constructing concrete floodwalls along the riverbank. However, the government has not yet done this.
8. About the garbage problem; there are no trash collection points available near by the community along the Ciliwung Riverbank. Even if it is available, it is difficult to collect since the road is very small and difficult to reach using garbage trucks. In this community, the Indonesian counterpart will distribute 100 questionnaires.

Figure7.1.1.2. Interview with the head of community in Cililitan

Location2: Condet Sub-district
Key organization: Komunitas Ciliwung Condet
1. A similar situation with location 1, the early warning in this community was broadcast using radio communication after receiving information from the upstream water gate.
2. The reason why most of people did not evacuate is also similar, that is fear for the security of their homes.
3. In this area, there are also no evacuation sites available, so those who evacuated during the January flood stayed in mosques and their family's houses.
4. The inconsistency in law enforcement becomes crucial; the problem of illegal housing along the Ciliwung Riverbank becomes a 'hot issue' only during times of flood. Otherwise, there is no enforcement to prevent proliferation in the number of illegal residents or disposal of trash in the river.
5. Some ideas to solve the garbage problem:
a. Technology for a community-level garbage recycling program (i.e. RW level)
b. River-line garbage collection technique (using boats). In this community, similar to location1, the Indonesian counterpart will distribute 100 questionnaires.

Figure7.1.1.3. Interview in community center at Condet

Site visit survey 13/2, 2013
Key organization: Komunitas Ciliwung Merdeka
Location3: Kampung Pulo and Bukit Duri
1. These two areas are the primary sites for the governor's plan to relocate squatters from the riverbank.
2. The community already has their own proposal for new low-cost apartments if they are relocated from the riverbank.
3. During the team's visit to this area, a flood of maximum depth 2 m was occurring and evacuation was still being conducted during the interview (Fig. 7.1.1.3).
4. The early warning in this area was obtained through the media
5. There are no official evacuation sites available.
6. The Head of village and sub-district was not involved.
7. The flood evacuation in this area is dependent on the community leader.
8. The economic resilience (even though they have no fixed job) is quiet strong. In the 2007 flood, within 3 weeks after the flood, their economic activity had recovered.
9. Another idea for the garbage in this area is garbage trading (one trash bag equal to 1 kg rice). In this area, the Indonesian counterpart will distribute around 250 questionnaires. Additionally, around 300 questionnaires are to be distributed in two junior and senior high schools located near the river.

Figure 7.1.1.4. Evacuation of people living nearby the Ciliwung River due to the 13 February 2013 flood.

Preliminary conclusions (findings) and further planning
Conclusions (findings):

1. Community leaders along the Ciliwung River were able to get 'warning' about whether or not flooding will occur by getting information about the water level at the upstream water gate (Katulampa). The lead time between flood in Katulampa and the downstream area is around 9 hours.
2. The primary cause why people did not evacuate is fear for security of their homes. If the security of their belongings can be guaranteed during evacuation, it is believed the evacuation rate will increase.
3. Another reason for the low rate of evacuation during the big flood is that no evacuation site is available. This becomes crucial for those who did not have families in non-flooded areas.
4. About the garbage problem in the Ciliwung River; there is a communication gap between the government and the community about the collection of the garbage from densely populated areas along the riverbank. The basic problem is limited access from designated collection points provided by the government to the densely populated areas along the riverbank. However, practical solutions from the community (i.e. garbage collection via boat on the river) can be a feasible idea.
5. Law enforcement is not consistent. The shantytown problem along the Ciliwung Riverbank becomes a 'hot issue' only during floods. In non-flood times, there is no supervision to prevent an increase in the number of illegal residents or improper disposal of trash.

Further planning:

1. One should note that the flood problem in Jakarta will not be solved by only assessing the hazard and physical countermeasures. Social aspects play a very important role in determining the successful use of physical countermeasures.
2. From the preliminary 'sensing the problem', there is not such a big influence of demographic aspects on determining the response of people during the flood. Therefore, the existing questionnaire can be applied to a wider area in order to catch more information and specific problems of each community.
3. In line with this research, the Indonesian counterpart (Indonesian University) is undertaking a similar initiative but their focus point is the behavior of people along the riverbank related to garbage and economy. However, both research projects can

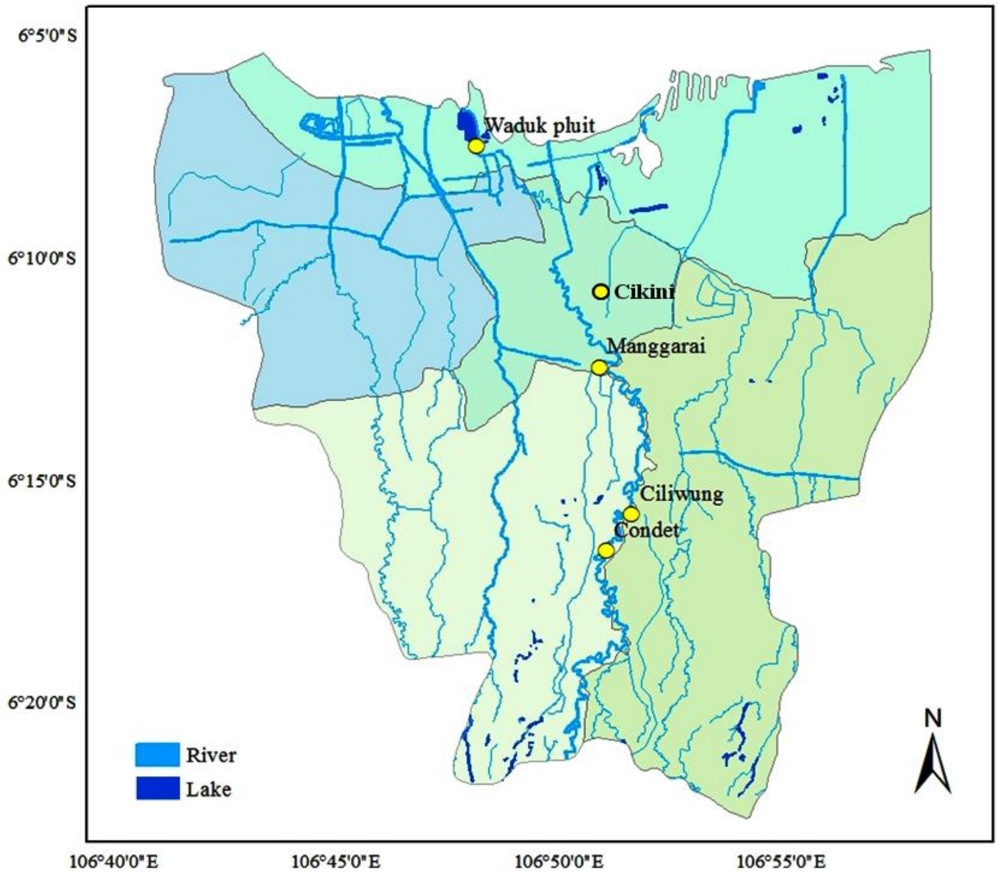
complement one another in order to obtain better information.

7.1.2. Survey results

Introduction

The questionnaire survey analyzed in this report is based on results from two different groups of respondents. The first group consists of household along the Ciliwung River, which frequently experience flooding when rainfall is stronger than the usual. The second group consists of students from a junior high school also located along the Ciliwung River, downtown near the presidential palace. As many as 154 residents and142 students were directly interviewed in the first and the second groups respectively. They responded to 38 questions, where two thirds were multiple-choice, and the remaining one third were free answer. The sequence of the respondents' answers indicated their opinion on the importance of the problem posed by the question. We applied general random sampling with no specific stratification criteria because of lack of demographic data before the survey. Also, information about the flood-impacted region in Jakarta City was not detailed enough to design stratification criteria for the respondents. This survey, therefore, is limited to preliminary sensing of the problem of social and psychological aspects of the flood problem in Jakarta by directly distributing questionnaires to the affected villages. We expect this survey can briefly explain the problems and gives clues as to whether or not further questionnaire surveys are needed with adjusted stratification criteria for better representation of problem identified as important by the first survey.

The questionnaire survey was initiated during the IRIDeS visit to Jakarta (10-13 Feb 2013) in two areas, namely Cililitan and Bukit Duri. A week later, the team from the Indonesian University (UI) and the Indonesian Institute of Science (LIPI) distributed the questionnaires and helped the respondents answer the questions. It took five days to complete the survey of the two groups at the locations indicated in Map 7.1.2.1.



Map7.1.2.1. Locations of the questionnaire survey conducted by IRIDeS, Indonesian Institute of Science (LIPI) and the Indonesian University in Jakarta (Condet, Ciliwung and Manggarai).

We compiled data from both groups to present and elaborate similarities and differences of the respondents' thoughts of each question from the questionnaire. Furthermore, the survey addressed three major topics: namely the evacuation issue, flood risk perception, and flood early warning. This report consists of two parts; the first is the presentation of results from the questionnaire survey, and the second is the discussion and remarks extracted from the analysis of the first part. Recommendations based on conclusions are drawn in the final section.

7.1.2. a. General Overview

In the first group, most of the respondents were parents with agees ranging from 30 to 50 years old, while in the second group most respondents are students in the first year of junior high school. The age distribution of respondents from both groups is shown in Fig. 7.1.2.1 below,

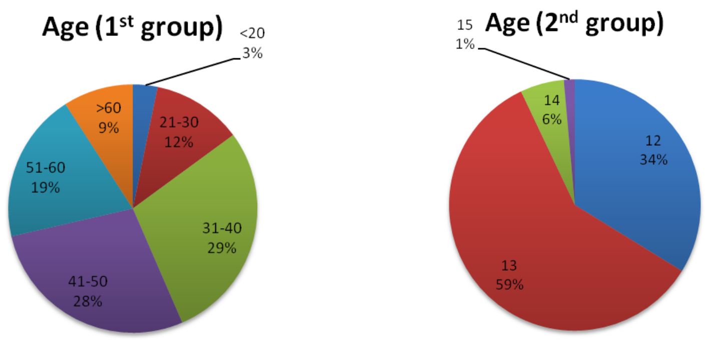


Figure7.1.2.1. Age distribution of the respondents from both groups

Among the respondents in the first group, 68.2% were female (Table 7.1.2.3). Among both male and female respondents, 54.5% of them have no fixed job, 29.2% work informally, 13.6% in private companies, and the other 2.6% were government employees (Table 7.1.2.4). That situation is underlying the fact that in general, a majority of the respondent had never received university-level education. Instead, their education is mostly limited to high school (45%), junior high school (42%), elementary school (39%) or no schooling at all (13%) (Table7.1.2.5).

Table7.1.2.3. Gender

	Frequency	Percent	Valid Percent	Cumulative Percent
Female	105	68.2	68.2	68.2
Male	49	31.8	31.8	100.0
Total	154	100.0	100.0	

Table7.1.2.4. Occupation

	Frequency	Percent	Valid Percent	Cumulative Percent
Government	4	2.6	2.6	2.6
Private	21	13.6	13.6	16.2
No fixed job	45	29.2	29.2	45.5
No job	84	54.5	54.5	100.0
Total	154	100.0	100.0	

Table7.1.2.5. Education

	Frequency	Percent	Valid Percent	Cumulative Percent
Never been to school	20	13.0	13.0	13.0
Elementary School	39	25.3	25.3	38.3
Junior High School	42	27.3	27.3	65.6
High School	45	29.2	29.2	94.8
Bachelor	6	3.9	3.9	98.7
Master	2	1.3	1.3	100.0
Total	154	100.0	100.0	

Based on the information of house ownership from the first group, we supposed that most of respondents are the natives in this area (so called Betawi people) who lived in their own house (45.5%) or are living with their parents (16.9%). The other 37.7% are migrants who rent houses/apartments (35.1%) or live with their brothers (2.6%) as shown in Fig. 7.1.2.2 (left). Regardless of where they come from, however, 79.2% of the

total respondents have been staying in this area more than 5 years (Fig. 7.1.2.3, left). Therefore, we assumed that many respondents experienced floods not only this year but also in previous years.
Similarly, students in the second group mostly lived with their parent and brothers (Fig. 7.1.2. 2, right) and have been in the present location more than five years (Fig. 7.1.2.3, right).

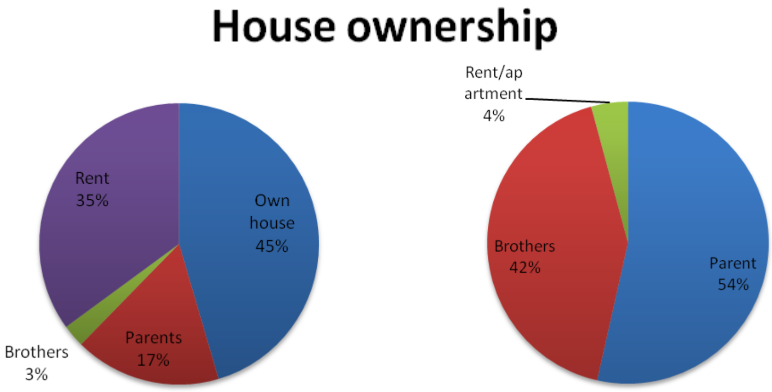


Figure7.1.2.2. House ownership among respondents in the first group (left) and the second group (right)

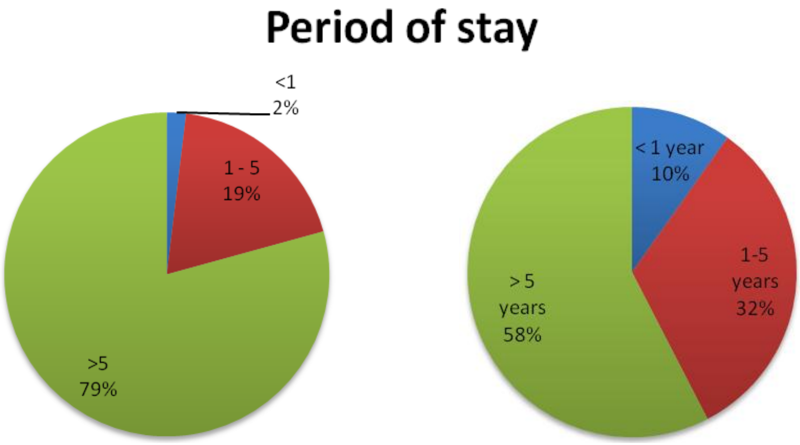


Figure7.1.2.3. Period of stay from people in the first group (left) and respondents from the second group (right)

7.1.2. b. Experience during the recent flood

In this section, we allowed respondents more than one answer to explore their perception about the cause of the flood, the type of flood that occurred, and some aspects related to their experience during the flood in January 2013. From an expert's point of view, the cause of the flood in January 2013 was the West monsoon period during December to February that brought high precipitation in Jakarta. If so, the water level in the upstream part of the river basin (Ciliwung) can be used as an indicator of whether or not a flood will occur once the Indonesian Meteorological Agency (BMKG) reports the rainfall intensity higher than usual. However some problems related to the behavior of people along the river, such as throwing garbage into the river, may have increased the intensity of flooding in the last decade. Floods now occur often even when the precipitation upstream is not too high, which indicates the drainage capacity of the river has become smaller. People who live along the river said that apart from flooding from upstream (23.8%), most of the people living along the river agreed that garbage disposal to the river is the major cause of the flood (31.5%), which causes siltation and constriction of the river width (13.3%). Surprisingly, the junior high school students also have a similar opinion that major flooding in Jakarta is not the caused solely by high intensity of the rainfall in the upstream catchment, but mostly caused by the reduction of river discharge capacity due to siltation and garbage disposal to the river (Fig. 7.1.2. 4).

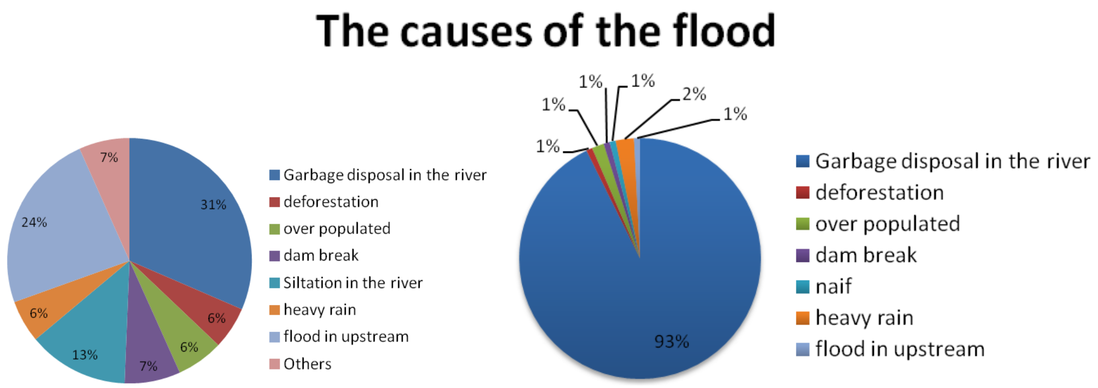


Figure7.1.2.4. Opinions of respondents of the first group (left) and the second group (right) about the major causes of flooding in Jakarta

Almost all respondents from the first group experienced the flood in January 2013 (79.2%). However, the situation is not similar to the respondents from the second group, where only 23% experienced the flood in January 2013. The respondents from the first group were mostly affected by the flood as a type of overflow from the river. On the other hand, respondents in the downtown area (second group) said that flooding nearby their houses was caused not only by river overflow, but also caused by insufficient ground infiltration since there was no water drainage path in the built area as well as inadequate drainage (Fig. 7.1.2.5).

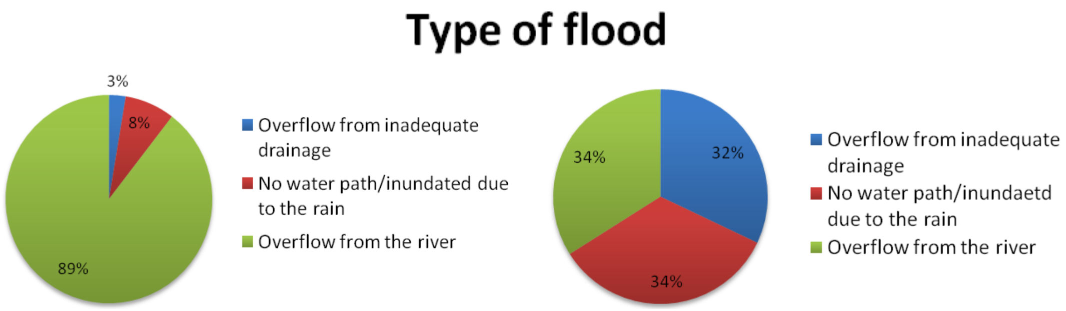


Figure7.1.2.5. The different of the flood type depends on the location of respondent.

The difference in the flood type as mentioned above implies that the second group experienced flooding more frequently than the first group. In downtown, water can easily inundate areas with inadequate drainage once the precipitation is slightly more intense than usual, or once the rain falls longer than usual (Fig. 7.1.2.6, right), but the flood depth is mostly less than 0.5 m (Fig. 7.1.2.7, right). On the contrary, people along the river experienced flooding mostly once in 5 years –which is the well-known return period for big floods in Jakarta– with a flood depth higher than 1 m.

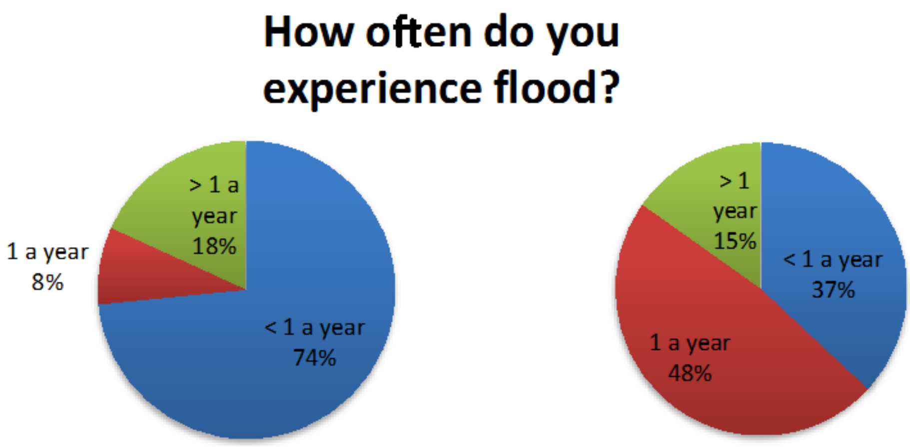


Figure7.1.2.6. Frequencey of floods experienced by respondents from both groups.

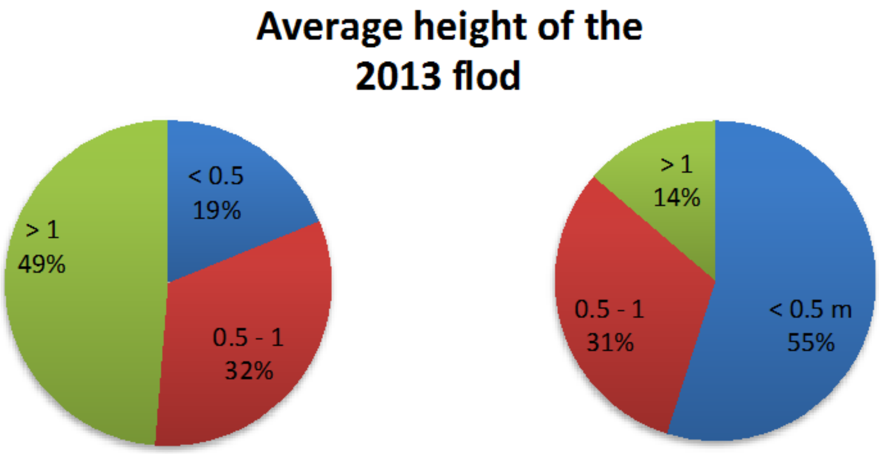


Figure7.1.2.7. Average flood depth experienced by the respondent in both groups during the 2013 Jakarta flood.

The experiences described above affect the estimated future maximum flood depth predicted by the respondents. Students from the second group think that flooding in their area will not exceed 0.5 m, as has happened so far. Similarly, past experiences yield a maximum flood depth of more than 1 m in the future as estimated by almost all respondents from the first group (Fig. 7.1.2.8).

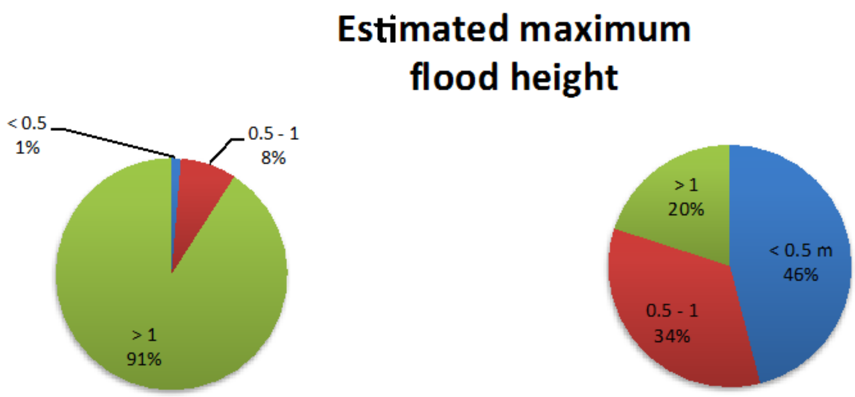


Figure7.1.2.8. Predicted maximum height of future flooding as estimated by the respondents.

Considering the impact of the recent flood, even though most houses from the first group were made from brick (51%, Fig. 7.1.2.9, left), 79% respondents said their houses suffered damage due to the recent flood (Fig. 7.1.2.10, left), where most of the damages affected furniture inside the house and wooden doors (Table7.1.2.6). This condition is reasonable since 18.8% of the total respondents from the first group experienced flooding deeper than 2 m (see appendix, Table7.1.2.10).
In the downtown, brick dominates the house material as well (Fig. 7.1.2.9, right). However, only 5% suffered damages during the 2013 flood (Fig. 7.1.2.10, right). This contradictory condition compared to the first group can be understood the flood depth affecting the second group was less than 0.5 m, which is not likely to damage house structures.

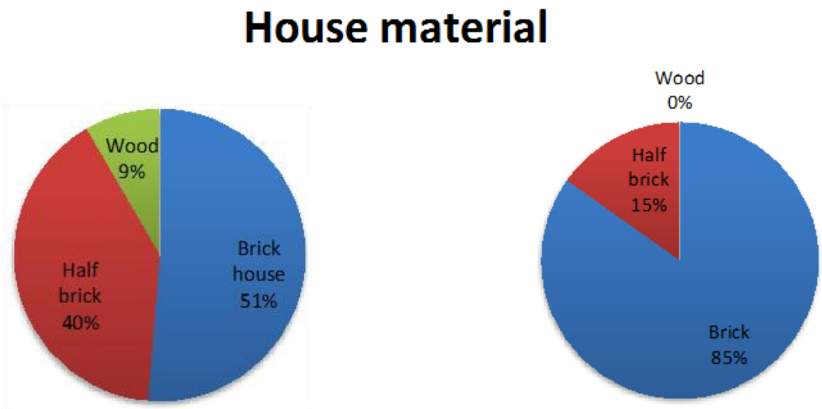


Figure7.1.2.9. Types of houses inhabited by respondents from both groups.

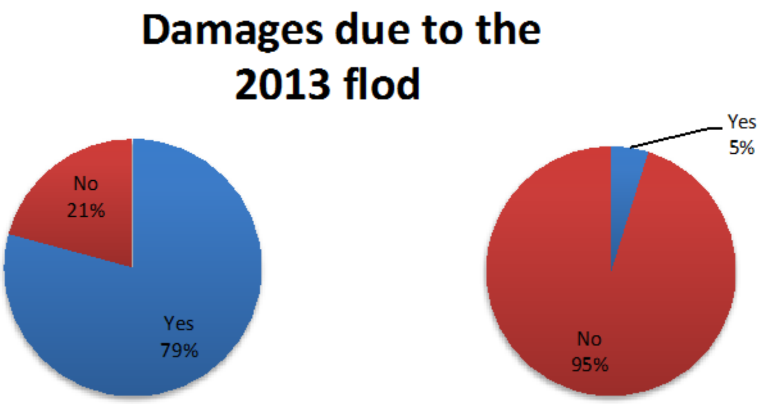


Figure7.1.2.10. Respondents whose houses suffered damages (or not) during the 2013 flood.

Table7.1.2.6. Type of damages during the flood in January?

	Frequency	Percent	Valid Percent	Cumulative Percent
Damage on furniture	67	26.4	26.4	26.4
Damage on the door	48	18.9	18.9	45.3
Damage in the wooden wool	24	9.4	9.4	54.7
Damage in the plafond	16	6.3	6.3	61.0
Others	13	5.1	5.1	66.1
Damage on ceramics	13	5.1	5.1	71.3
Damage on the wall's paint	12	4.7	4.7	76.0
Damage on the bulkhead	10	3.9	3.9	79.9
Damage on the roof	8	3.1	3.1	83.1
Damage on the stilt toilet (in the river)	7	2.8	2.8	85.8
Damage on the electronics	7	2.8	2.8	88.6
Damage on the window	5	2.0	2.0	90.6
Damage on the floor	4	1.6	1.6	92.1
Lamp	3	1.2	1.2	93.3
Kitchen	2	.8	.8	94.1
Bathroom	2	.8	.8	94.9
Damage on the window platform	2	.8	.8	95.7
Damage in the water pump	2	.8	.8	96.5
Electricity set	2	.8	.8	97.2
Damage in the ladder	2	.8	.8	98.0
Damage in the cattle (died)	2	.8	.8	98.8
Dirty water contaminated wells	1	.4	.4	99.2
Damage on the fence	1	.4	.4	99.6
Damage in the wooden structure	1	.4	.4	100.0
Total	254	100.0	100.0	

Nevertheless, people from the first group made some efforts to minimize the damages to their houses and belongings such as furniture by moving them to them 2nd floor, placing temporary sand bags, and trying to make additional dikes along the river (Fig. 7.1.2.11, left). These efforts were only significant in the first group even though as many as 20% of respondents from the second group also moved their furniture to the 2nd floor to minimize the impact of flood to their houses and interiors (Fig. 7.1.2.11, right).

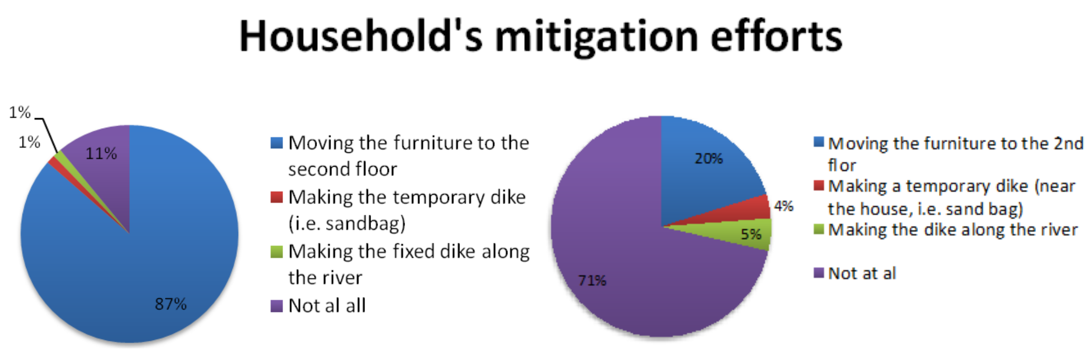


Figure7.1.2.11. Distribution of respondents from both groups who made efforts to reduce the flood impact to their houses.

7.1.2. c. Evacuation Issues

Moving to the issue of human safety, 83.8% of all respondents in the first group evacuated during the flood in January (Fig. 7.1.2.12, left). Most of them began evacuation soon after the flood occurred on 15 January 2013 (54.3%, Table7.1.2.7), which was the first day of the flood. The main reasons for those who evacuated are the unexpected height of flood in their houses and duration of the flood that persisted for several days (42.6%). Another reason that seems to be correlated with the first answer is the fear of getting trapped in the flood (33.3%) that makes people evacuate once the flood depth increases beyond their expectation (Fig. 7.1.2.13, right).

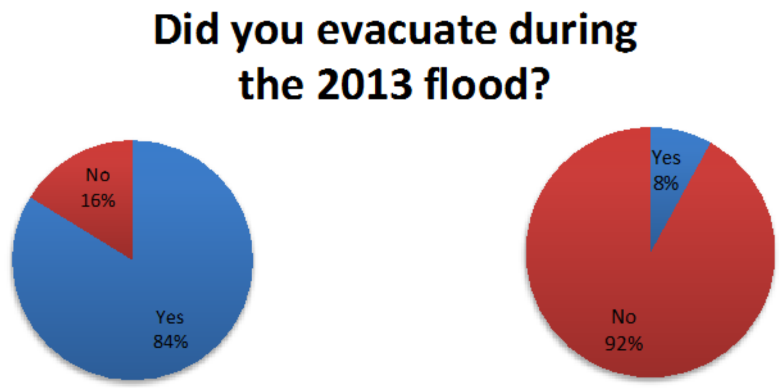


Figure7.1.2.12. Evacuation response of people from both groups during the 2013 Jakarta flood.

Table7.1.2.7. When did you start the evacuation?

	Frequency	Percent	Valid Percent	Cumulative Percent
1 Januari	1	.6	.8	.8
12 Januari	2	1.3	1.6	2.3
14 Januari	9	5.8	7.0	9.3
15 Januari	70	45.5	54.3	63.6
16 Januari	19	12.3	14.7	78.3
17 Januari	24	15.6	18.6	96.9
18 Januari	4	2.6	3.1	100.0
Total	129	83.8	100.0	

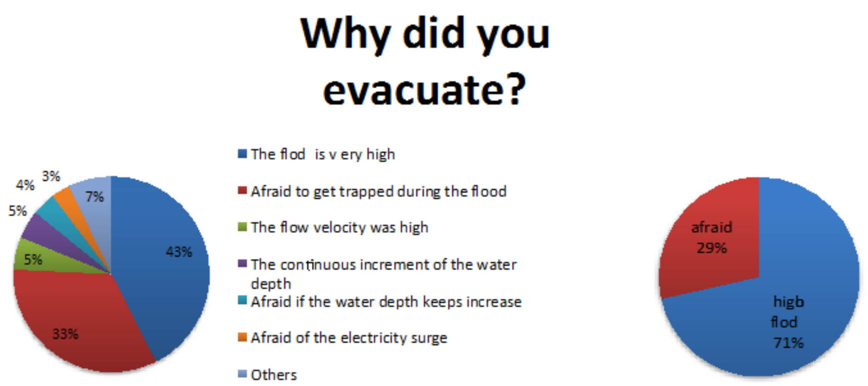


Figure7.1.2.13. Reasons why some of the respondendents were evacuate during the 2013 flood.

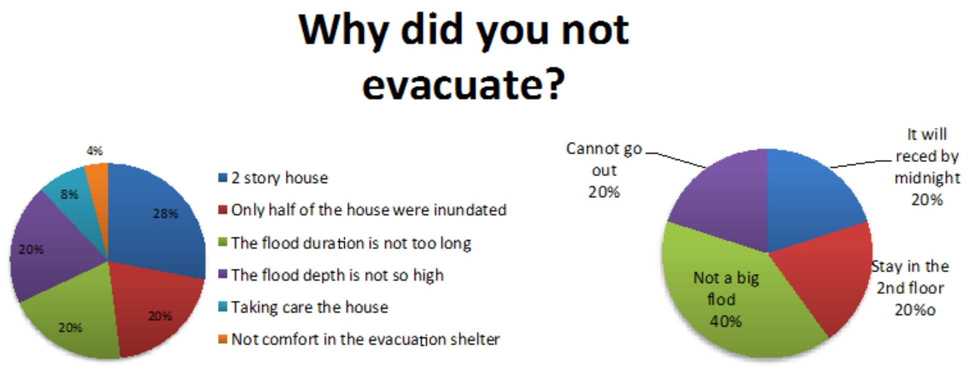


Figure7.1.2.14. Reasons why some of the respondents did not evacuate during the 2013 flood.

For those who did evacuate, most of them evacuated to surrounding neighbors' homes that were not affected by the flood (29.5%, Fig. 7.1.2.15). The reason for this option is the safety of their abandoned property (house). Evacuation to more distant places means it becomes more difficult to check and control whether or not their houses are safe from thieves or from the flood it self. Another options was to go to relatives' houses (25.6%), the nearest evacuation shelter (15.5%), schools (13.2%) and mosques (9.3%), which are also some of the designated place to evacuate (Table 7.1.2.19).

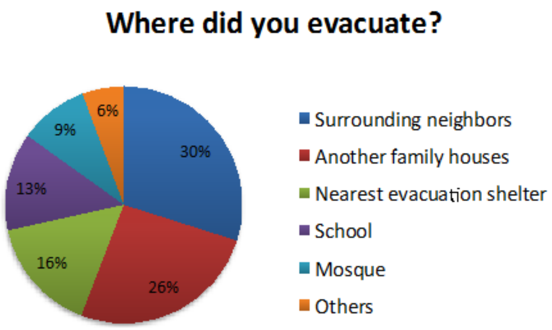


Figure7.1.2.15. Evacuation destinations chosen by respondents during the 2013 flood.

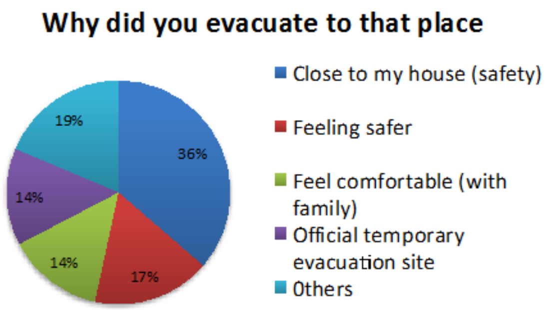


Figure7.1.2.16. Underlying reasons in selecting evacuation destinations.

The sequence of the respondents' answers indicates that there was no systematic evacuation in case of flood especially in areas where most of the poor people live. The official temporary evacuation sites stated in Fig. 7.1.2.16 are not evacuation buildings that were officially built for evacuation, rather they can be village government buildings, schools or mosques that were used during the flood to facilitate emergency aid distribution during the flood.

For those who did not evacuate, they stayed in the second floor (28%) of their homes since the water in this area only inundated the lower story of their houses (20%) and the inundation lasted less than 4 hours (20%). Also, for those who experienced previous floods higher than this one, they decided to not evacuate because they think they are still able to manage the risk (20%).

7.1.2. d. Flood risk perception

To explore in more detail the perception of flood risk related with the above presented results, we posed several questions to elaborate people's opinions about flooding in their area. We first asked whether or not the respondents felt that flood can threaten their safety. Interestingly, we found a contradictory result between the first and the second groups. By having experiences several big floods, a majority of respondents in the first group said that flood is threatening to their safety (72.1%). However, 64% of respondents from the second group said the flood cannot harm them (Fig. 7.1.2.17).

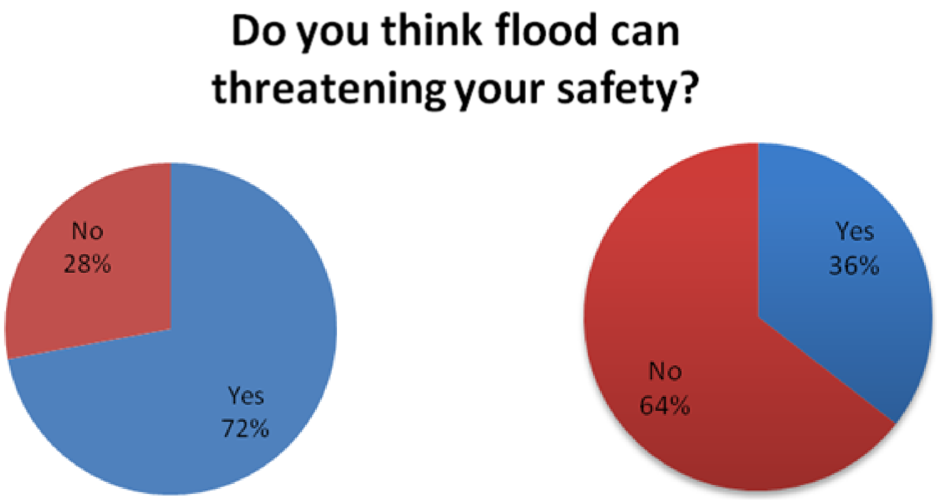


Figure7.1.2.17. Public perceptions about the dangers of floods.

Our hypothesis that the above perception should relate with the experiences had by the people in the first group seems to be correct. Further explanation about the reasons why people in the second group thought that flood can harm them: they said that they are afraid to be swept away by a strong current and/or afraid to be drowned by the high flood (Table7.1.2.8). This condition can only occur in a case of flood caused by overflow of water from the river, which is not likely to occurr in the downtown area of the second group.

Table7.1.2.8. What is the reason you think the flood can threatening your safety?

	Frequency	Percent	Valid Percent	Cumulative Percent
Afraid to be swept or drowned due to the strong current and high flood depth especially for the children and elderly.	69	44.8	62.2	62.2
Flood usually followed by desease outbreaks	21	13.6	18.9	81.1
The water level can increase very fast	7	4.5	6.3	87.4
Flood can damage the houses (near the river)	5	3.2	4.5	91.9
During the flood, many harmfull debris (i.e. glass, broken bottle) and wild animal (i.e. snake, big lizard) cannot be seen.	3	1.9	2.7	94.6
Usually some electrical surge happened	3	1.9	2.7	97.3
Hypothermia	2	1.3	1.8	99.1
Cannot work during the flood	1	.6	.9	100.0
Total	111	72.1	100.0	

In the result of the questionnaire survey in the first group alone, different characteristics of flooding in different villages influenced the lowering of risk perception of those who thought that flood is not threatening their safety and decided not to evacuate during the flood in January. They argued that floods in their area were not so high and the flow velocity was not so fast (41.9%, Table7.1.2.9). Their experience facing several floods also created an adaptive capacity where they measured when they should evacuate and when should not (23.3%). Related with the latter is the answer that some of the respondents were still able to evacuate even after the flood had already occurred (9.3%) and also already had prepared to mitigate the impact of the flood (9.3%).

Table7.1.2.24. What is the reason you think the flood is not threatening your safety?

	Frequency	Percent	Valid Percent	Cumulative Percent
The water level and flow velocity are not so high	18	11.7	41.9	41.9
Already get used with the flood	10	6.5	23.3	65.1
Still able to evacuate	4	2.6	9.3	74.4
Already have preparation to mitigate the flood impact and always aware with the flood information	4	2.6	9.3	83.7
Experience that the flood has never been killed people in their area	3	1.9	7.0	90.7
The house location is in the high ground level	2	1.3	4.7	95.3
There is an evacuation door to the house nearby located in the higher ground level	1	.6	2.3	97.7
The river is visible to be checked whether or not the flood can threatening the safety	1	.6	2.3	100.0
Total	43	27.9	100.0	

We are next moving to a straightforward question to identify the threshold of flood that people thought can be dangerous to their safety. In the questionnaire, we classified answers based on three classifications of flood, namely ordinary flood, big flood but not dangerous, and big and dangerous flood. The results of the questionnaires are shown concurrently as follows,

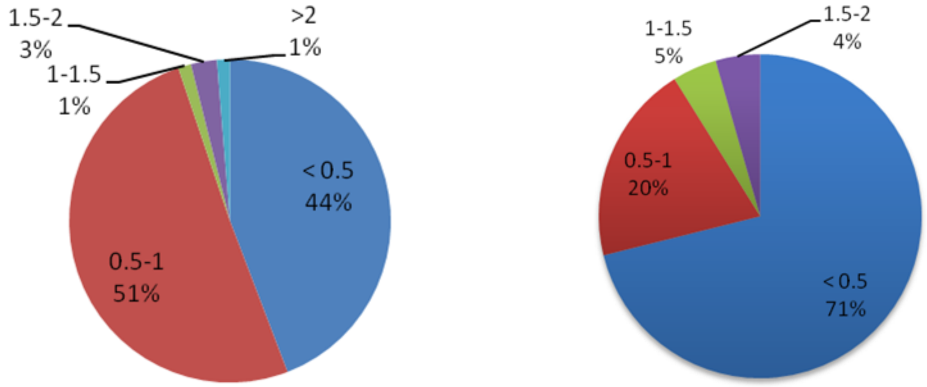


Figure7.1.2.18. People's perception about the height of flood categorized as normal flood.

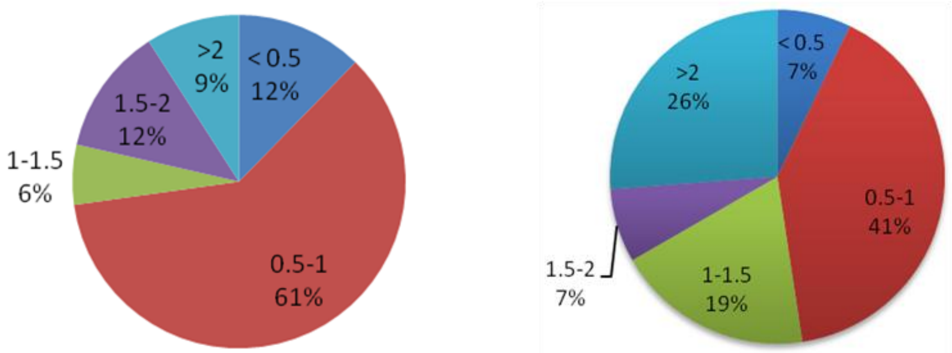


Figure7.1.2.19. People's perception about the height of flood categorized as big flood.

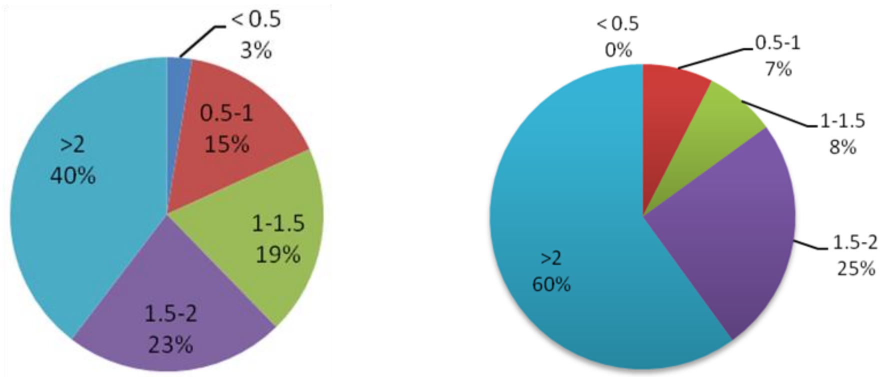


Figure7.1.2.20. People's perception about the height of flood categorized as big and dangerous flood.

The results in Figs. 7.1.2.18-7.1.2.20 indicate that people from both groups agreed that big and dangerous floods are those with a depth more than 2 m, but there is some confusion in the first group when distinguishing which should be categorized as normal flood and which is a big but non-threatening flood. More structuralized answers are obtained from respondents in the second group. Even though they had not experienced big, or big and dangerous floods as categorized in Figs. 7.1.2.19 and 7.1.2.20, they can clearly distinguish the difference among the three classifications. It is not clear whether or not the level of education is playing a role so the people in the second group can give clearer answers compared to the people from the first group, because there were 38% of the total respondents in the first group with less education than the people in the second group.

Based on the above perception particularly for the people in the first group, some possible mitigation efforts to reduce the potential impact of recurrent flooding are needed. Among the various options, relocation is one of the priorities that the government of Jakarta is currently attempting to implement. We explore the opinions of the people from the first group regarding the option to be relocated from their existing locations. The aim of doing this is to see whether or not their perception of risk about flood affects the decisions they make for their daily and future lives. Surprisingly, even though 79% of them suffered damages during the 2013 flood, 56.5% of them have no willingness to evacuate from their present locations (Table7.1.2.9) because they already got used to flooding and consider the impact of flooding as an acceptable risk (25.7%, Table7.1.2.9). These people said that it is true they will have a month with flood every year, but they also have the other 11 months to live normally. Another strong reason for them to stay is the present location is proximity to the places where they can have various informal jobs such as construction labor, goods coolie, small business, garbage man, etc. Based on our interview with a local leader, he said people restarted their economic activities in this area just three weeks after the largest flood in 2007. Thus, we assumed that economic vulnerability has more influence in determining decisions for their daily lives, rather than their environmental condition of being exposed to flood hazards.

For those who have willingness to be relocated, the main reason for them is because they already have grown tired of flooding (46.3%), but the biggest problem for them for not relocating by now is limited funding resources to start new lives in new places (23.9%).

Table 7.1.2.9. Do you want to move from the present location?

	Frequency	Percent	Valid Percent	Cumulative Percent
Yes	67	43.5	43.5	43.5
No	87	56.5	56.5	100.0
Total	154	100.0	100.0	

Table 7.1.2.10. If not, why?

	Frequency	Percent	Valid Percent	Cumulative Percent
Comfortable with the present situation	29	6.3	25.7	25.7
Economic income located very closed with the present location	16	3.5	14.2	39.8
Present location close to the children's school	10	2.2	8.8	48.7
Born in this place	10	2.2	8.8	57.5
Present location is very good	9	1.9	8.0	65.5
The only house located in the present location	8	1.7	7.1	72.6
Not enough money to move	7	1.5	6.2	78.8
Big flood occurs only 1 in five years, and this flood also affects the other people (not only me)	6	1.3	5.3	84.1
Comfortable with the neighbor	6	1.3	5.3	89.4
Comfortable with the environment	4	.9	3.5	92.9
Comfortable with the society	3	.6	2.7	95.6
Native	2	.4	1.8	97.3
Difficult to move	2	.4	1.8	99.1
Low living cost	1	.2	.9	100.0
Total	113	24.5	100.0	

Table 7.1.2.11. If yes, why?

	Frequency	Percent	Valid Percent	Cumulative Percent
Tired to the flood	31	20.1	46.3	46.3
Tired to the flood but no money to move	16	10.4	23.9	70.1
Tired to the flood but if the government want to pay the moving, it will be OK	13	8.4	19.4	89.6
Not comfortable with the present situation	4	2.6	6.0	95.5
Live under the flood threat	3	1.9	4.5	100.0
Total	67	43.5	100.0	

7.1.2. e. Early warning

One of the issues we would like to assess through the questionnaire survey is the flood early warning system, warning dissemination process and procedures, system equipment and whether or not the warning can reach the most vulnerable community particularly along the Ciliwung River and also people in the other places that can be potentially affected by the flood. Our concern is based on the reported casualties during the 2013 flood in the basement of a business building near downtown. Even though later it was found that the casualties might have occurred due to the underestimation of or the ignorance of the flood hazard (which is also related to the evacuation and the risk perception of the flood), the existence of an early warning may be useful to avoid casualties in the future.

Before asking the respondents about what and how effective the early warning is, we asked them whether or not they were warned that flood would come before it occurred on January 15.

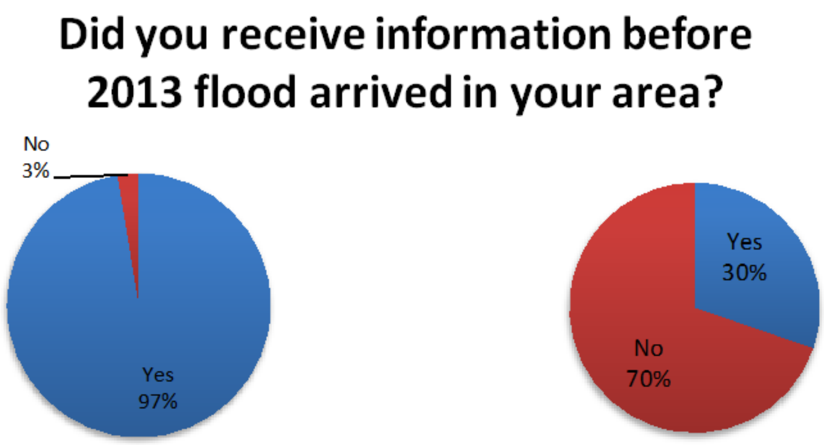


Figure7.1.2.21. Availability of flood early warning during the 2013 flood based on information from respondents in the first group (left) and people from the second group (right).

It can be seen that people in the first group received information before the flood arrived in their area, while most of people in the second group did not. Thus, we first assumed that flood early warning is indeed available along the Ciliwung River. Our assumption was strengthened by a report on the development of flood early warning in Jakarta named PROMISE (PROMISE, 2009). This system was preliminarily applied in two areas: Kebun Baru and Bukit Duri, where the latter is one of the locations where the second group of respondents are located. There was no further information about whether or not this system has been applied in other areas in Jakarta. We therefore asked the respondents in both groups about the existence of the flood early warning system in their communites/areas as shown in Fig 7.1.2.22.

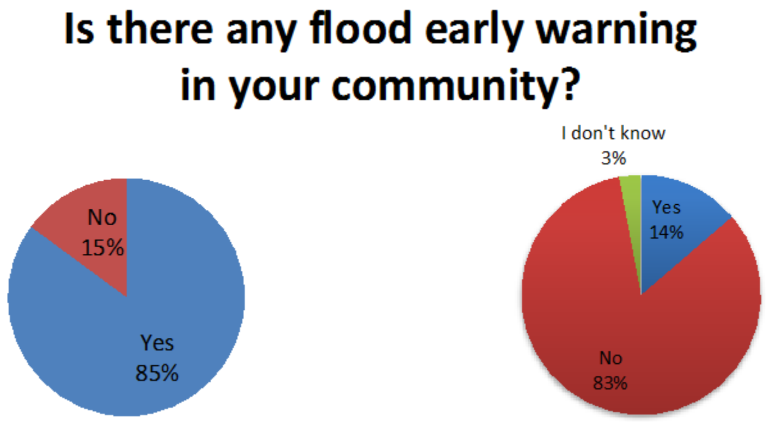


Figure7.1.2.22. The questionnaire results about the existence of flood early warning in the areas of the first (left) and the second groups (right) based on information from respondents.

In a simple representation, results in Figs. 7.1.2.21 and 7.1.2.22 indicate that the flood early warning is established in the first group because of the frequency of big floods experienced by the people in this area. Even though people in the second groups does not receive an 'early warning' as indicated by people in the first group, they all agreed that such system is important (Fig. 7.1.2.23).

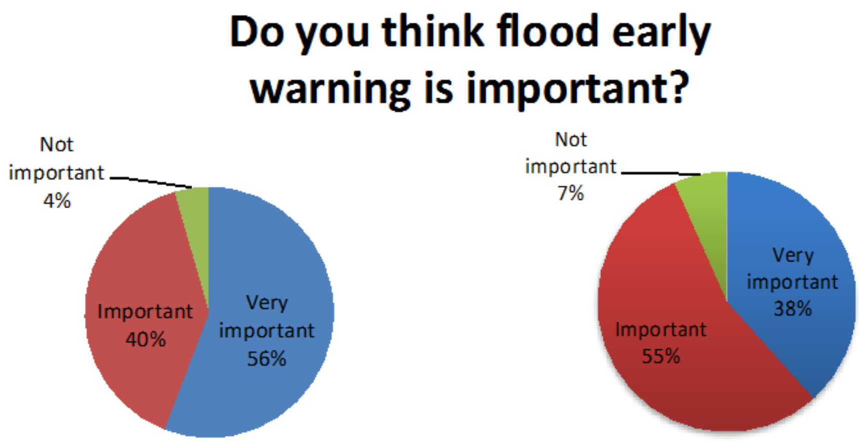


Figure7.1.2.23. The necessity of the flood early warning system based on opinions of respondents in the first group (left) and in the second group (right).

We are next asking further information about the flood early warning in the second group. Among the 85% of respondents who said that there is a flood early warning system in their area, 91% of them said that the 'system' worked well during the 2013 flood (Table7.1.2.12). However, the so called 'early warning system' is not the one we assumed as a comprehensive and integrated system that consists of equipment for measurement and the dissemination of the warning. The early warning system mentioned by the people in the second group is a kind of chain information among the villagers (mostly started by the announcement of the village/local leader) that inform residents of the water level condition at the water gate in the upstream area. This was revealed by the question asking from whom the respondents obtained the information about the flood as is shown in Fig. 7.1.2.24.

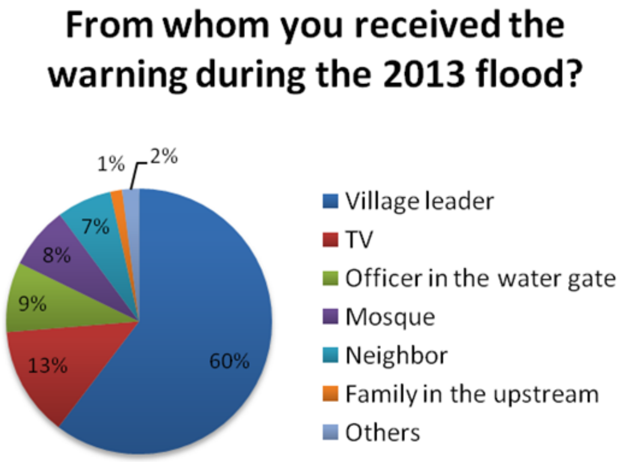


Figure7.1.2.24. The sources of information about the potential occurrence of flood in the 'community based early warning' developed among the villagers of the first group.

This community-based system of course has weaknesses. It relies on manual dissemination mostly through word of mouth, 45.5% of the 8.4% respondents who said that the system did not work well during the 2013 flood argued that the warning sometime comes very late, is not accurate (18.2%), does not reach the community along the river bank (18.2%) and sometimes the warning is just based on the prediction of the local leader (18.2%, Table7.1.2.13). Nevertheless, the warning was issued by the village/community leader after obtaining information about the water level at the upstream-most water gate namely Katulampa. From this point, it takes 9 – 12 hours for the flood to reach the study area. After receiving the warning, therefore, the community still has time to clarify and respond to the warning (Table7.1.2.14) by removing important documents, electronics, and school books from the first floor of their house (60.7%). Some of them (9.8%) decided to monitor the water level and keep awake during the night (7.1%).

Table 7.1.2.12. Did the system works well during the 2013 flood?

	Frequency	Percent	Valid Percent	Cumulative Percent
Yes	120	77.9	91.6	91.6
No	11	7.1	8.4	100.0
Total	131	85.1	100.0	

Table7.1.2.13. If it was not working well, why?

	Frequency	Percent	Valid Percent	Cumulative Percent
Information comes late	5	3.2	45.5	45.5
Information is not accurate	2	1.3	18.2	63.6
Information did not reach community in the river banks	2	1.3	18.2	81.8
The warning sometimes just based on leader perception and prediction	2	1.3	18.2	100.0
Total	11	7.1	100.0	

Table7.1.2.14. What is your respond after receiving the warning?

	Frequency	Percent	Valid Percent	Cumulative Percent
Preparing documents, school books, clothes, electronics and etc.) to be taken to the shelter and moving things to the 2nd floor)	68	44.2	60.7	60.7
Monitoring the water level	11	7.1	9.8	70.5
Being alert and prepare	8	5.2	7.1	77.7
Tell the neighbor that flood will come	7	4.5	6.3	83.9
Gathering the family to evacuate	6	3.9	5.4	89.3
Did not anything because it will not going to be flood	5	3.2	4.5	93.8
Confuse	4	2.6	3.6	97.3
Moving things to the surrounding neghbor that is not flooded	2	1.3	1.8	99.1
Looking for informations to the officer in the upstream water gate to confirm the water level.	1	.6	.9	100.0
Total	112	72.7	100.0	

7.1.2. f. About garbage management at the community level

The classical problem for people who live near the river bank is garbage disposal to the river. We added some questions in the questionnaire to briefly investigate the problem. At first, most of people said that they are not sorting the garbage into recyclable and non- recyclable garbage (88.3%, Table7.1.2.15). This does not only happen in low-income populated areas where the poor live, as the garbage management at the city level also does not require people to sort the garbage into recyclable and non- recyclable garbage. People think the garbage will be collected and disposed of in the same place.

At the household level, their waste is directly burned (77.8%, Table 7.1.2.41) because there is no garbage processing facility (18.4%), people are too lazy to do the garbage processing (17.6%) and have no knowledge about waste management (15.4%). At the village level, garbage management is conducted by the government, which provides trash collecting points and expects people will put their garbage there (40.3%, Table7.1.2.43). However, the locations of the garbage collecting points are mostly far from the poor dwellers near the river bank. So, garbage disposal into the river becomes the only choice for the poor (29.2%).

Table7.1.2.15. Did you do the garbage sorting and process in your house/community?

	Frequency	Percent	Valid Percent	Cumulative Percent
Yes	18	11.7	11.7	11.7
No	136	88.3	88.3	100.0
Total	154	100.0	100.0	

Table7.1.2.16. If yes how did you do the garbage process?

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Burn the garbage without sort it	14	9.1	77.8	77.8
	Burn the garbage by previously sort the recycle and non-recycle ones	3	1.9	16.7	94.4
	Recycle the garbage	1	.6	5.6	100.0
	Total	18	11.7	100.0	

Table7.1.2.17. If not, why?

	Frequency	Percent	Valid Percent	Cumulative Percent
No facility	25	16.2	18.4	18.4
Lazy	24	15.6	17.6	36.0
Did not know the way	21	13.6	15.4	51.5
That is the job of the garbage man	20	13.0	14.7	66.2
Even I did, it still will be the flood because all people do the garbge disposal to the river	11	7.1	8.1	74.3
Already the in the garbage collection points	11	7.1	8.1	82.4
Dump the garbage into the river is more easy and practice	10	6.5	7.4	89.7
Only small household garbage	4	2.6	2.9	92.6
No time	4	2.6	2.9	95.6
Meaningless because it will be mixed again in the garbage collection points	3	1.9	2.2	97.8
No leader on garbage management	3	1.9	2.2	100.0
Total	136	88.3	100.0	

Table7.1.2.18. How is the garbage management in your community?

	Frequency	Percent	Valid Percent	Cumulative Percent
Government provides the garbage collection points for people to put their garbage	62	40.3	40.3	40.3
No management, thus people dump it into the river	45	29.2	29.2	69.5
Garbage man collects it and people pay him together.	27	17.5	17.5	87.0
No management, just directly burn it	13	8.4	8.4	95.5
Garbage man collects it but he is not reach community in the river banks	4	2.6	2.6	98.1
Government provides garbage collectin points and garbage man	2	1.3	1.3	99.4
No garbage management	1	.6	.6	100.0
Total	154	100.0	100.0	

7.1.2. g. Conclusions

1. Contrary to the opinions of experts related to the cause of the flood, people from both groups thought that flood in Jakarta, particularly the one that occurred in January 2013, was caused by garbage disposal to the river that yields siltation and is lowering the river discharge capacity.

2. There are two types of floods mentioned by the respondents that differ from the first group to the second group. The overflow of water from the river is the dominant event in the first group, which occurs once in five years with a relatively high flood depth. In the other hand, more periodic flooding happens among the second group, which is characterized by local inundation with a very shallow flood depth due to the built infrastructure and inadequate drainage that causes less ground infiltration.
3. The difference in the type of flood as well as their hazards yields a contradictory perception about flood risk between the two groups. People in the first group deeply thought that flood can harm their human safety, while respondents in the second group think the flood does not endanger them.
4. As a consequence of point 3, there was no initiative at the community level to develop their own early warning in the second group, though the first group had developed such a system.
5. To date, there is no systematic flood early warning system that consists of equipment for flood measurement and warning dissemination available or being used by the locals in either group. The 'flood early warning' mentioned in this questionnaire survey is a developed chain of information passed by word of mouth among the locals.
6. The garbage problem is a result of the increase of population along the river banks where the conventional system of garbage collection designed by the government cannot reach the densest population along the river. A practical solution is needed to overcome this problem.

7.2. Public health

The 2013 flooding of Jakarta has caused a direct public health problem because of deaths, injuries, displacement and damage to health facilities. The flood not only caused direct impact to public health, but also had indirect impact, due to damage to houses, roads, and other public facilities. Electricity in some areas experienced outagesfor a few days, and the regional water company could distribute clean water. These troubles caused further problems for public health.

In addition, the floods have resulted in severe environmental contamination. Overflow water from drains and rivers spread garbage, other waste, and pathogens all over. In addition, septic tank overflows sent feces everywhere. Environmental contamination clearly has a considerable negative impact to public health, and one of the diseases that may occur after flooding is leptospirosis.

Leptospirosis is a zoonotic bacterial disease that is widespread and is transmitted through contact of the skin and mucous membranes with water, damp vegetation, or mud contaminated with rodent urine. Infected rodents shed large amounts of leptospires in their urine. Leptospirosis is also known as flood fever because it appears after flooding. In some countries, leptospirosis is known as icterohemorrhagic fever, stuttgart disease, illness well, canicola fever, swineherd disease, swamp fever, or mud fever. Flooding facilitates the spread of the organism due to the proliferation of rodents and the proximity of rodents to humans on shared high ground.

In the event of major flooding in Jakarta in 2002, over a hundred cases of leptospirosis were reported, with 20 deaths. Severe flooding that occurred in early 2007 again led to an explosion in the number of cases of leptospirosis, with 248 cases reported and more than 19 deaths.

Unlike after Jakarta's previous floods, cases of leptospirosis have not been reported in 2013, even though most of Jakarta's population has no access to sewage or septic systems, meaning that floodwaters inevitably contained much human and animal waste. This is despite the fact that the Indonesian Ministry of Health estimates that 50% of mice in Jakarta suffer from various types of leptospirosis, meaning that mouse urine can spread the leptospira to other mice, other animals, and to humans.

Analysis of water quality samples is underway to determine whether dilution of this waste with floodwater may have been a reason for the lack of leptospirosis in the 2013 flood. We collected water samples from 8 locations in Ciliwung, Manggarai, Condet, Waduk Pluit, Kampung Melayu, and Bidara areas (Figure 7.2.1). We used three methods to analyze the water samples: Loop-mediated isothermal amplification, microscopic observation, and isolation.

From the analysis, we found that all of the samples are contaminated with bacteria and/or protozoa. Some samples we collected from Manggarai, Condet, Kampung Melayu,and Bidara contain spirochete, but from nonpathogenic species. These nonpathogenic species are free living and indigenous to fresh surface water. They don't cause any disease, different from their relative, pathogenic spirochete, which causes Leptospirosis.

Further environmental analysis and more environmental samples are needed to assess the risk factor for the community, whether during normal conditions or during disaster.

We have to understand that a lack of reported cases doesn't mean no cases at all, as the lack of reporting could possibly due to suboptimal patient tracking, underdiagnosis, or misdiagnosis. Leptospirosis may be present with a wide variety of clinical manifestations. These may range from a mild "flu"-like illness to a serious and sometimes fatal disease. It may also mimic many other diseases, e.g. dengue fever and other viral haemorrhagic diseases. Difficulties in confirming the clinical manifestation using laboratory tests also makes leptospirosis overlooked and underreported.

Although there were no reported cases of Leptospirosis in January 2013, flooding caused a massive displacement of communities. On January 21, 2013, the number of refugees was as many as 45,344 people. Indeed, the number of refugees is gradually shrink along with shrinking of pool of water. On January 30, 2013 for instance, the number of refugees was only 1,228 people. Displacement is a very important factor in infectious disease spread after disaster. The risk for communicable disease transmission after disasters is associated primarily with the size and characteristics of the population displaced, specifically the proximity of safe water and functioning latrines, the nutritional status of the displaced population, the level of immunity to vaccine-preventable diseases such as measles, and the access to healthcare services.

Flooding has also resulted in many losses, both of possessions and of lives. A total of 52,180 people were displaced. 33 people died due to various reasons, from being swept away in the river, drowning, electric shock, and several illnesses. Based on official record, as many as 94 people suffered serious injuries that required hospitalization, whereas 45,978 people experienced minor injuries or only needed outpatient care. Meanwhile, 57 health care facilities (5 hospitals and 52 primary health care clinics) were damaged by the flood.

Flooding in Jakarta has led to public health problems among the population. Data recorded from January 17 to January 26 suggests that many people had been infected with several diseases. Prominent among them were acute respiratory infections, diarrhea, gastritis, typhoid, and skin disease. This could have been caused by the continuing rain, the cold, and lack of hygiene and sanitation in the refugee camps.

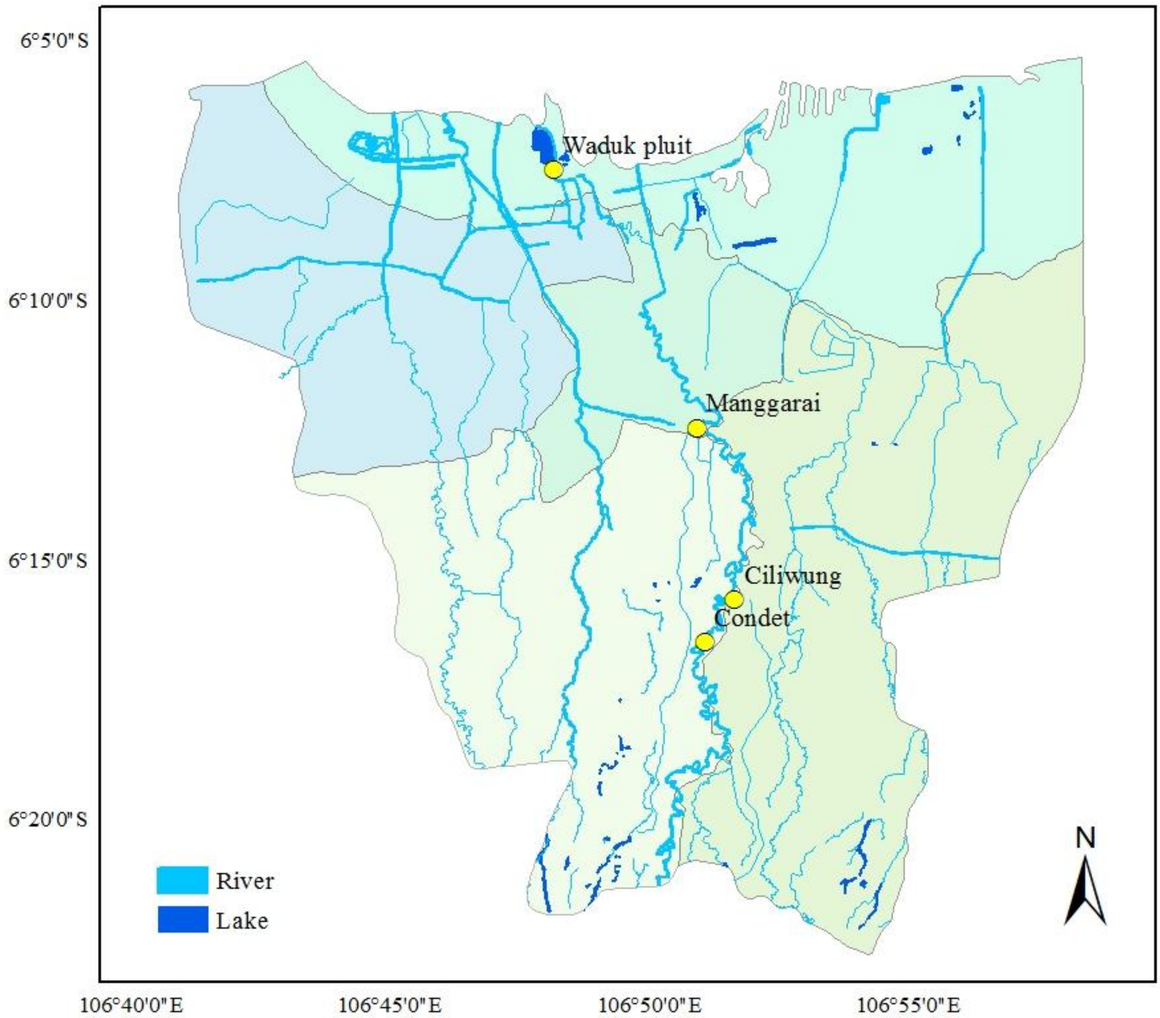


Figure 7.2.1. Map of water sampling sites.

7.3. Industries

Included among flood countermeasures in Jakarta are those enacted by private companies. Tokiomarine Indonesia (TMI) has underwritten the damage insurance for private companies and autonomous bodies located in Jakarta city, and paid insurance once claims after flood events. As a matter of course, insurance company staff visit the damaged sites and investigate the extent of damage before the company pays insurance claims. Therefore, TMI has a great store of information on flood damage and countermeasures regarding private companies. On this visit, we interviewed TMI staff, who also took us to one private company located in Pulogadung Ward in Jakarta city.

First, TMI staff explained the flood situation in Jakarta city;

・When areas around east canal were inundated, water level in east canal was not so high. This indicated that drainage around east canal didn't work well. We think this is one important problem (Figure 7.3.1).

・A lot of private company customers are located in Pulogadung Ward and Sunter Ward, and were subjected to flooding long after the initial flood subsided.

・Some areas of southern Jakarta experienced high flood flow velocities.

・The highway from the city to the airport has flooded every rainy season since 2009. The same situation recurred this year (Figure 7.3.2).

・The insurance company has determined that industrial areas in eastern Jakarta city around the Citarum river have low flood risk. Therefore, most customers have located in these low flood risk areas.

Following this, we visited a Japan-affiliated company site in Pulogadung Ward and learned about their flood countermeasures from company staff. As for structural measures against flood, the company built a strong wall around the site circumference, prepared drainage pumps/ sandbags / boats, developed water retention ponds, elevated the road around the site, and installed power generators. Basically, the company built a reinforced concrete wall around the site circumference, and installed pumps to evacuate rainwater that falls within the site. The wall is about 1m in height (Figure 7.3.3). The retention ponds were developed inside the site to store accumulated water (Figure 7.3.4). Both fixed and portable pumps were present to evacuate water. The capability of all pumps is about 90ton/sec which is thought to be more than sufficient. The fixed pumps are elevated about 50cm so as not to be submerged (Figure 7.3.5). Sandbags were prepared around entrance gates for guards to deploy at any time (Figure 7.3.6). In addition, the company has elevated the surrounding road about 1m on its own budget. The height of elevation was decided by the inundation height in 2007. This countermeasure against flood worked well in 2013, as the company didn't flood.

As for non-structural measures against flood, the company has contingency plans. The trigger for enacting emergency procedures is a dangerous water level as reported by the BMKG (Badan Meteorologi, Klimatologi, dan Geofisika) water level gauge or the company's own level gage (Figure 7.3.7). The guards work 24 a day and check these water levels throughout the day. They also inspect and prepare pumps/generators/sandbags before each coming rainy season by using inspection sheets so as not to miss important points. Emergency evacuation drills are conducted every year. Furthermore, the previous inundation depth is drawn on walls inside the industrial park, so company staff are constantly reminded of the flood threat.

This Japan-affiliated private company has implemented many countermeasures against flooding by dedicating sufficient budget to this purpose. They had more advanced countermeasures than even private companies in Japan. This indicates that Jakarta city has a higher flood risk than Japan does. However, it is not so easy for inhabitants to spend their own individual incomes on flood countermeasures. Therefore, they face a high potential risk of flood inundation. As one measure to solve these problems in the future, we should consider cooperationi between private companies and inhabitants in the construction of flood countermeasures.

Figure 7.3.1. Flood water level of the East drainage canal.

Figure 7.3.2. Flooded road to Jakarta Airport.

Figure 7.3.3. Strong reinforced concrete wall as countermeasure against flood.

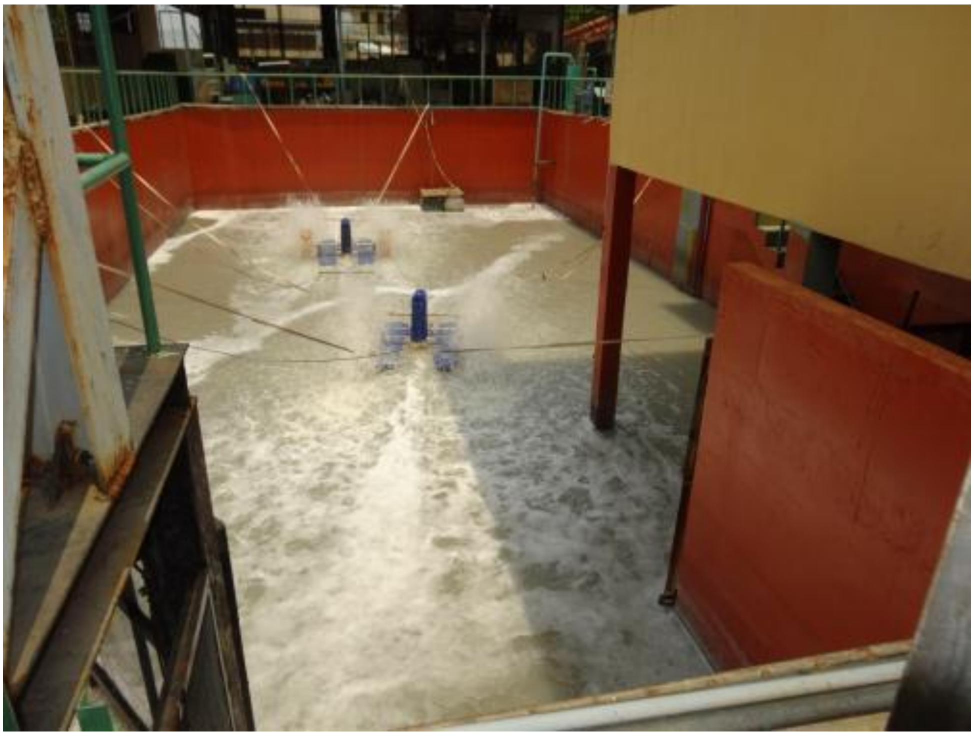


Figure 7.3.4. Water retention pond at the private company site.

Figure 7.3.5. Elevated fixed drainage pump at private company site.

Figure 7.3.6. Sandbags and floodwall.

Figure 7.3.7. Water level gauge.

8. Recommendations

Hydrologic and hydraulic analysis of Jakarta's flood control system is ongoing, but analysis undertaken so far has produced the following recommendations:

1. Inspection of drainage canal embankments followed by normalization of embankment crest height and removal or proper bulkheading of encroaching structures.
2. Development of a flood-fighting program to find and patch canal embankment problems before breaches occur.
3. Public health education to minimize contact of residents with disease-ridden floodwaters.
4. Education to prevent residents from disposing of trash in waterways, as the trash might be reducing the drainage capacity of these waterways.
5. City trash collection sites convenient for residents of riverside/canalside shantytowns.
6. Education to stress the urgency of evacuation.
7. Cooperation between industries and government, so that critical transportation infrastructure, which is essential for industries to operate, can be protected from flooding.

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