Ministry of National Development Planning
National Development Planning Agency of Indonesia

The Simulation Study on Climate Change in Jakarta, Indonesia

Final Report

(Summary)

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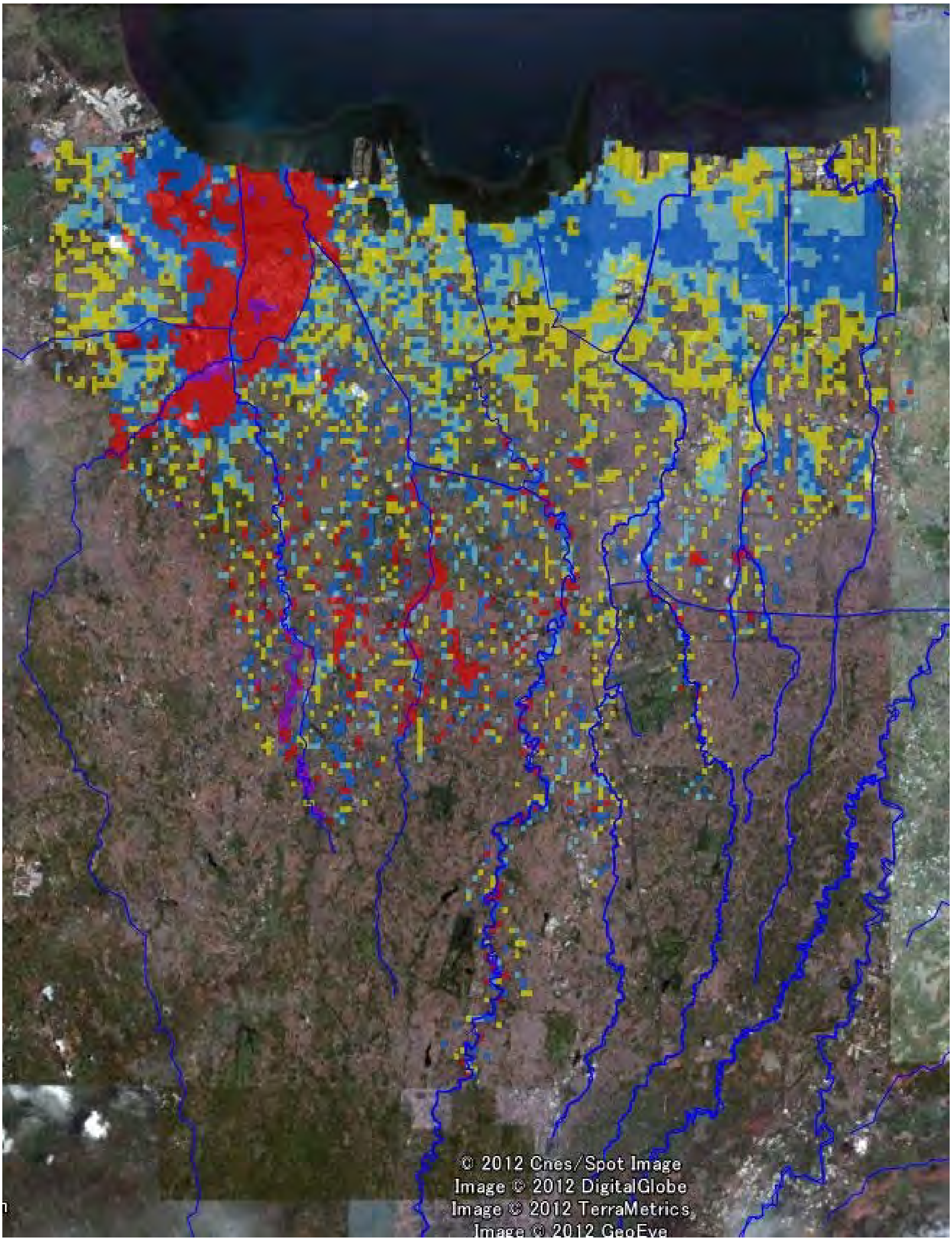
Japan International Cooperation Agency (JICA)

Yachiyo Engineering Co., Ltd.



Flood Simulation in DKI Jakarta (Scenario: 2050_F_MP_A1FI_V2_100)

EXECUTIVE SUMMARY

BACKGROUND AND OBJECTIVE

In 2010, Japan International Cooperation Agency (JICA), World Bank (WB) and Asian Development Bank (ADB) conducted a joint-study on impact analysis by climate change focusing on mega-cities in Asia which are highly vulnerable to climate related risks under global warming.

JICA has taken up this Study on mega-city Jakarta, Indonesia as a follow-up case study by applying the methodologies established in the above-stated joint study, with specific objectives such as i) to understand climate-related risks in Jakarta in 2050, ii) to assess impact of flood due to climate change and iii) to make policy recommendations which are worthy of being recommended for both the local and central government of Indonesia.

APPROACH AND METHODOLOGY

Two IPCC climate change scenarios were selected; viz., A1FI: a high emission scenario and B1: a low emission scenario. Non-climate change factors such as land use change and land subsidence were also considered, and these parameters were used as inputs to the flood simulation. In addition to this, assumptions and estimates were made regarding infrastructure scenario for flood control in 2050. As a result, a total of 45 cases of simulation under 3 different return periods (1/10, 1/30 and 1/100) was carried out and analyzed to provide information of area, volume and depth, etc. of flooding. Based on the results obtained from flood simulation analysis, impact of flood was assessed in terms of damage costs. It is noted that in the approach and methodology, various influential assumptions with regard to climate scenarios as well as socio-economy were applied.

In Jakarta, in 2009, approximately 320 thousand people live under the poverty level which is then called as the poor. The government has issued several assistance programs for the poor. Taking the importance of poverty issues into consideration, this Study conducted a household survey on the urban poor in the selected villages (Kelurahans) in Jakarta to figure out impacts of flood inundation on the poor and to make policy implications to be addressed by the governments.

KEY FINDINGS

From the result of flood simulation analysis, it is found that;

- Jakarta is likely to suffer from flood especially due to inner water in consideration of the characteristics of rainfall, inundation, topography, and the state of flood infrastructure.
- In the case that land subsidence is in progress in Jakarta, it causes flood due to inner water because inundation water accumulated in urban area is not properly discharged to the sea. Therefore, the possibility that floods cause not only economic but also social damages in large scale would become extremely high.
- Considering the increase of rainfall volume and sea level rise due to climate change, flood damage due to inner water increases for the same reason described above.
- Consequently, serious flood damage can occur in Jakarta due to the progress of urbanization of land use, the effect of climate change, and further progress of land subsidence.
- Therefore, it needs to establish comprehensive flood management in Jakarta including countermeasures against climate change and land subsidence, land use regulations and improvement of river and storm drains etc., considering the whole river basin.

From the result of damage cost assessment for 45 cases, it is found that;

- The damage costs in 2050 resulting from both climate change and other factors such as land subsidence and land use change were estimated to be substantial and can range from Rp 56,660 Billion for the minimum to Rp 143,786 Billion for the maximum in 2050. This, in terms of the current GRDP in 2008, constitutes approximately 8.4 percent and 21.2 percent respectively.

- Land subsidence is more significant than climate-related factor in increasing flood damage cost. In comparison of damage costs with different condition about climate change and land subsidence in 1-in-30-year return period which is a medium-sized flood, of the total increase, approximately 79 percent is due to land subsidence. In terms of GRDP 2008, it accounts for about 9 percent.
- In view of damage costs by sector, damage to buildings and assets was estimated the largest among other sectors, with about 74 percent of the total damage costs.
- Not all the districts of Jakarta are evenly affected due to flooding. There is likely to be a severe flooding in the downstream area of the Cengkareng Channel in the northwest of Jakarta (Jakarta Barat) and a part of Jakarta Utara and Jakarta Timur including the coastal areas of the Jakarta Bay.
- Pumping Station Project (PS Project) which was taken up as one of the adaptation options in this Study (760m^3/sec. in 12 drain districts) will result in a significant reduction of damage costs at approximately 30 percent compared to "without PS Project scenarios.

A number of problems and issues with regard to the poor in Jakarta are evident from household survey and its analysis. Vulnerability includes physical factors such as small and fragile structure of houses and limited infrastructure, economic factor such as lack of savings, lack of insurance and lower income, social factors such as high population density, lower education levels. Thus, the survey concludes that these vulnerable conditions need to be addressed in order to formulate appropriate and effective policies for the poor.

RECOMMENDATIONS

Based on the analysis and findings as stated above, the following recommendations can be noted:

- As the finding shows, land subsidence would contribute the largest share of damage cost from flood (about 79 percent). Thus, it is recommended that countermeasures to slow down land subsidence are the subject of urgency for the government. They may include, for example, control of extraction and use of groundwater, conversion of main water source to surface water from groundwater, resettlement of major consumers of groundwater like manufacturing industries in Jakarta, etc.
- Urban planning and flood control infrastructure need to be prepared with proper consideration on climate-related risks. This includes review/revise of the existing rules, regulations about urban planning and land use, such as zoning regulations, development permits and so on.
- In addition, it is effective to implement a comprehensive flood control measures, especially for inundation areas where frequent and severe flooding is expected due to increased runoff discharged from upper stream. It includes, for instance, some measures such as designation of flood-prone area or hazardous proximity, establishment of early warning system, construction of rainwater storage facilities to cope with flood caused by inner water, etc., which are now under discussion in the Project for Capacity Development of Jakarta Comprehensive Flood Management being implemented by JICA.
- Establishment of Flood Risk Management Plan will be of paramount importance in view to reduce the risk of floods of both regular flooding and a certain flooding beyond prediction. This plan needs to be prepared in relation to residential, commercial and industrial use.

From the result of analysis on the urban poor, at the central government level, it is recommended to introduce: i) control of urbanization process with consistent and continuous policies, ii) monitoring of the data on the urban poverty, and iii) land use mechanism utilizing spatial management by monitoring and evaluating condition of vulnerable areas.

Whereas, at the local government level, it is recommended to introduce: i) enhancement of community-led socialization and internalization of local environmental management, ii) enhancement of land use planning and zoning regulations in addition to the law enforcement of building code and land use permit, iii) development and spatial plans taking the vulnerability and adaptation assessment into consideration and iv) intervention by the government in increasing the adaptive capacity of the poor.

PRIORITY ACTIONS

We conclude this report with highlighting some actions to be taken by the governments (at central and local government levels) with priority as follows:

- Studies on status quo of extraction and use of groundwater and impacts by excessive amounts of groundwater drawing (local government level);
- Planning, implementation and completion of switching water resources to those other than groundwater (local government level);
- Intervention by the government in formulation and enactment of consistent and continuous policies and strategies that manage resettlement of business and industrial units, including improvement and development of adequate infrastructure and facilities associated with re-location (local government level);
- Implementation of flood control infrastructure based on the existing Master Plan 1997 (central government level);
- Implementation of countermeasures for runoff control to cope with inadequate channel capacity (local government level);
- Review and revise the existing rules, regulations and other instruments concerning land use planning and zoning regulation etc., including housing administration policies that seek to minimize vulnerability to flood and to improve housing and working conditions (local government level); and
- Carrying out Flood Risk Assessment for preparation of Flood Risk Management Plan (central and local government level).

Flood in GROGOL SELATAN (2007)

Flood in WBC Underpass (2007)

<Extract from Key Findings: Flood Damage in Jakarta>

In Jakarta, flood damage increases mainly due to the progress of land subsidence, climate change, and the urbanization of land use. Of the total increment of flood damage, flood damage derived from climate change accounts for 15%, while flood damage due to land subsidence in consideration of the condition of ground water and topography in Jakarta accounts for 65%.

Tables and figures below show the result of inundation analysis such as flood area, flood volume and flood depth by two factors: climate change and land subsidence. The upper tables and figures indicate the impact of climate change, and the lower indicate that of land subsidence.

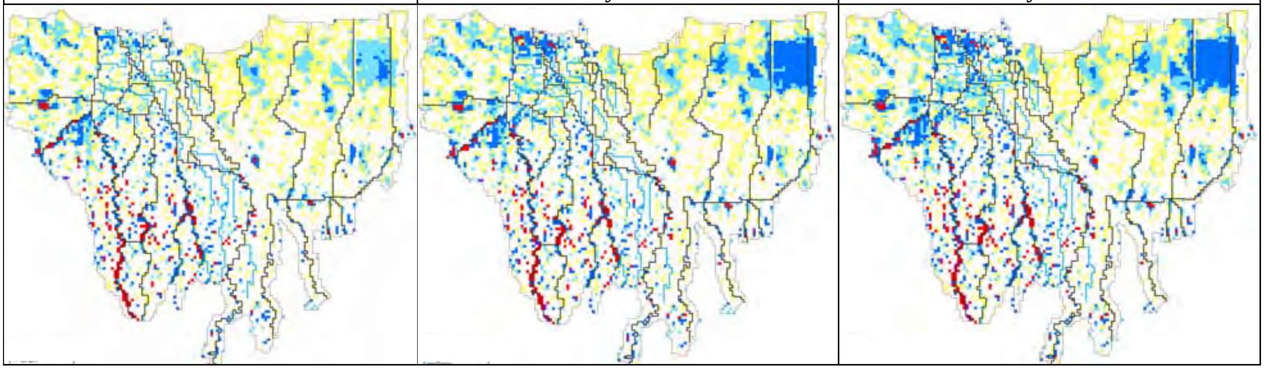
Case name in Tables below is composed of [Year]_[Land Use]_[Flood Infrastructure Scenario]_[Climate Change Scenario]_[Land Subsidence]_[Return Period]. For example, the case "2050_F_MP_A1FI_v0_100" indicates [2050]_[Future Land Use Condition]_[Master Plan Scenario]_ [Growth-Oriented Society Scenario]_[No Land Subsidence Compared to 2008]_[1-in-100-year flood].

In each factor, the extent of flood damage increases from case (A) to case (C).

Impact of Climate Change

Case Name	(A) 2050_F_MP_**P**_v0_100	(B) 2050_F_MP_**B1**_v0_100	(C) 2050_F_MP_**A1FI**_v0_100
Flood Area	243.4 km^2 (100%)	264.0 km^2 (108%)	277.1 km^2 (114%)
Flood Volume	$159.7\times10^6 m^3$ (100%)	$190.0\times10^6 m^3$ (119%)	$210.0\times10^6 m^3$ (131%)
Flood Depth	0.66m (100%)	0.72m (110%)	0.76m **(115%)**

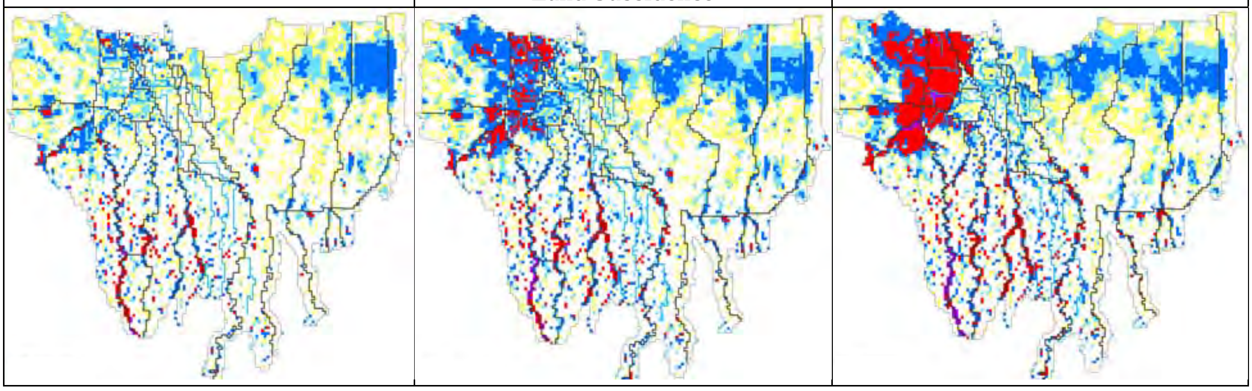
(A) Present Condition	(B) Sustainable Development Society Scenario	(C) Growth-Oriented Society Scenario



Impact of Land Subsidence

Case Name	(A) 2050_F_MP_A1FI_**v0**_100	(B) 2050_F_MP_A1FI_**v1**_100	(C) 2050_F_MP_A1FI_**v2**_100
Flood Area	277.1 km^2 (100%)	317.3 km^2 (115%)	331.2 km^2 (120%)
Flood Volume	$210.0\times10^6 m^3$ (100%)	$314.3\times10^6 m^3$ (150%)	$410.5\times10^6 m^3$ (195%)
Flood Depth	0.76m (100%)	0.99m (131%)	1.24m **(164%)**

(A) No Land Subsidence	(B) Relatively Stable Land Subsidence	(C) Severe Land Subsidence



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Land Use **F**: Future condition in 2050

Flood Infrastructure Scenario **MP**: Master plan scenario

Climate Change Scenario

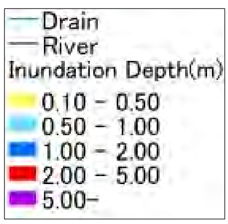
P: Present condition, **B1**: Sustainable development society scenario,

A1FI: Growth-oriented society scenario / Set importance on fossil energy resources

Land Subsidence **v0**: No land subsidence relative to 2008,

v1: Relatively stable land subsidence, **v2**: Severe land subsidence

<Map Legend>



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CHAPTER 1 Overview of Study

1.1 Background of Study

International society has begun to recognize global warming as the most critical issue of this century and work on the reduction of GHG emission (mitigation) as well as adaptation to the effect of global warming.

In Asia, since mega-cities along the coasts are expected to increase in number and grow in size with the development of economy, implementation of global warming impact analysis and establishment of measures for mitigation and adaptation to the global warming influences in such mega-cities are subjects of urgent.

In this situation, Japan International Cooperation Agency (JICA), World Bank (WB) and Asian Development Bank (ADB) conducted joint study "Climate Risks and Adaptation in Asian Coastal Megacities" in 2010 focusing on mega-cities in Asia which may be influenced greatly by global warming, for the purpose of (1) impact analysis by temperature rise and sea level rise (2) impact analysis on socio-economy (3) preparation of measures for "adaptation" and "mitigation" etc.

In this Study, socio-economic impact in Jakarta Metropolitan area due to climate change including temperature increase and sea level rise will be analyzed by applying the methodologies developed in the previous joint study, with eyeing the possibilities of simplifying the methodologies. Moreover, policy implication which is worthy of being recommended for future infrastructure development etc. will be identified based on the results of the above analysis.

1.2 Objectives of Study

This Study was implemented as the follow-up case study of WB-ADB- JICA joint study and applied the methodologies of the joint study (importance of flood measures, necessity of land subsidence containment, and comprehension of impacts on the poor, etc.).

The main objectives of this Study is i) to understand climate-related risks in Jakarta, ii) to assess the impact of flood due to climate change on the future socio-economy in Jakarta, and iii) to make policy recommendations for structural as well as non-structural adaptation measures.

1.3 Scope of Works

The Study consists of components as summarized below:

a. To estimate the scale of disaster from flooding based on the collected data including historical climate information etc.;
b. To model climate scenarios that are related to rainfall change, sea water level rise, high tide and land subsidence;
c. To estimate, with different climate and flood control infrastructure scenarios for 2050, potential areas to be affected and magnitude of damages by river flooding and flooding in the coastal zone caused by sea level rise, high tide as well as land subsidence;
d. To identify the most vulnerable urban resources to flooding, including communities, infrastructure, utilities etc., by means of collecting sector information (energy, transportation, water supply/sanitation, public health, building and housing etc.)., including present and future socio-economic conditions in Jakarta;
e. To estimate damage costs from floods in 2050 based on the result of flood simulation and assess direct and indirect impacts on socio-economy of Jakarta;
f. To conduct household survey on the urban poor and assess direct and indirect effects on the urban poverty group; and
g. To make policy recommendations for potential adaptation measures.

1.4 Study Area

Study area is shown in Figure- 1.4.1.

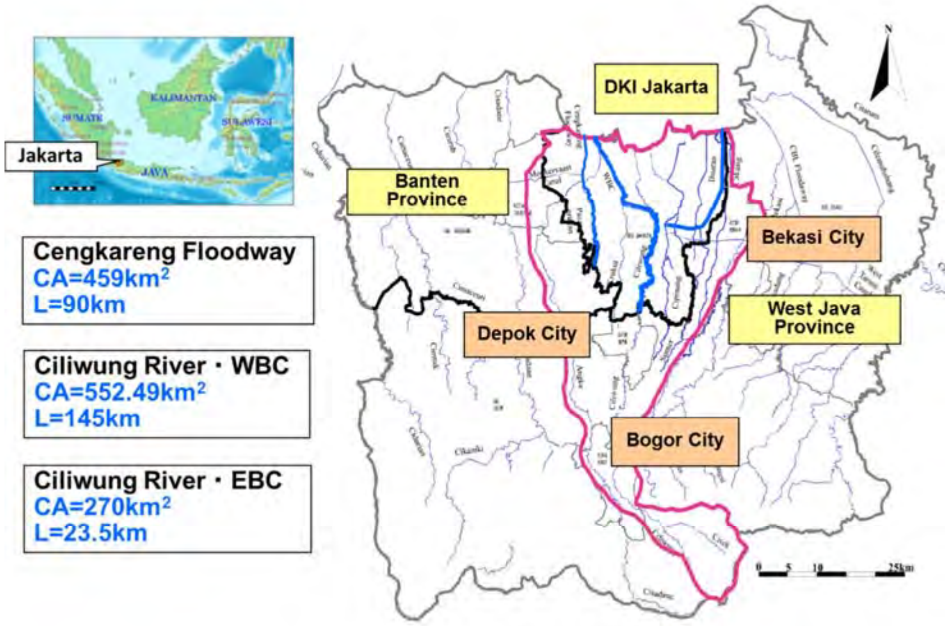


Figure- 1.4.1 Study Area

Flood in GROGOL SELATAN (2007)

Flood in MANGGARAI GATE (2007)

Flood in WBC (2007)

Flood in WBC Underpass (2007)

Figure- 1.4.2 Flood in Jakarta (2007)

CHAPTER 2 Present Condition of Study Area

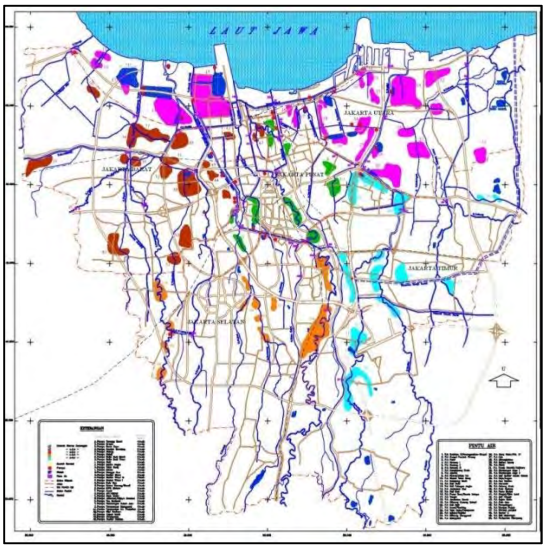
2.1 Topographical Feature

The Study area includes three rivers whose total size of catchment areas is 1,281km^2 and the total length is 258.5km extending over West Java Province, Special Capital Region of Jakarta (DKI Jakarta), and Banten Province. The average ground level in the Study area which ranges from -1m to 3,000m. The general conditions from upstream area to downstream area are summarized as follows:

- Upstream area from Bogor to Mt. Pangrango is mountainous area with an altitude of 300~3,000m;
- Midstream area from Manggarai to Bogor shows a gradual slope with an altitude of 20~300m;
- Downstream area is lowland area with an altitude of -1m~20m; and
- About 20 percent of DKI Jakarta located in the lowland area is below sea level with an altitude of less than 2m.

2.2 Flood Inundation Status

In the Jakarta Metropolitan area, the major flood has occurred in 1996, 2002 and 2007. Figure- 2.2.1 and Figure- 2.2.2 show a record of inundation area of floods in 2002 and in 2007 at DKI Jakarta. Inundation area reached 87km^2 (about 13 percent of DKI Jakarta) in the 2002 flood and 300km^2 (about 45 percent of DKI Jakarta) in the 2007 respectively.

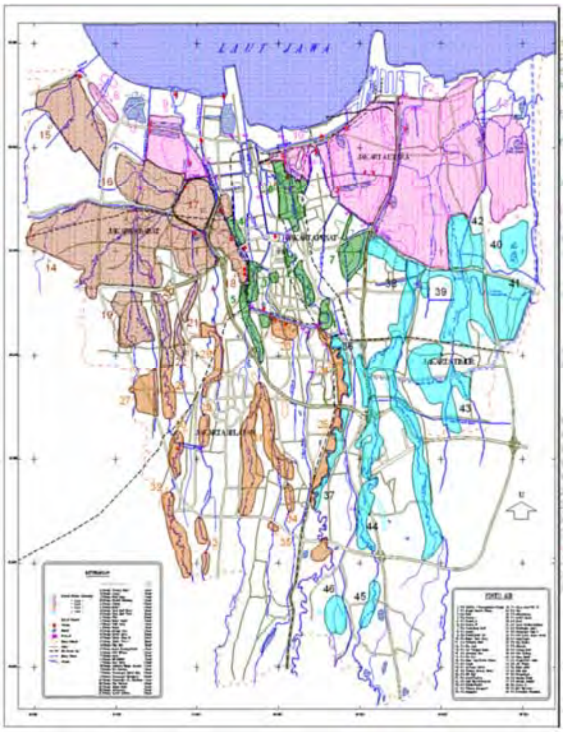


(The map above)

Figure- 2.2.1 Inundation Areas in 2002 Flood

(The map on the left)

Figure- 2.2.2 Inundation Areas in 2007 Flood



2.3 Land Use Change

In the basin of rivers flowing down in DKI Jakarta, land development has reached to the upper and middle stream areas owing to the accelerating concentration of population and industries. Consequently, it results in the increase of water discharge.

2.4 Condition of Climate Change

In recent years, changes in annual rainfall patterns probably caused by global warming have become conspicuous, and it is forecasted that climate change risks such as prolonged dry seasons, decrease in rainfall volume, and increase in concentrated downpours would be higher in the future. In Jakarta Metropolitan area, 1–9 percent increase in average annual maximum rainfall by rainfall duration compared to 1989-1998 as well as 1999-2008.

2.5 Condition of Land Subsidence

The Ciliwung-Cisadane river basin is experiencing extensive land subsidence with the development of JABODETABEK area in downstream areas (the northern metropolitan areas of Jakarta). The main factors behind this phenomenon are supposedly excessive extraction of groundwater in urbanized areas and the decrease of the volume of groundwater recharge owing to the residential development of the southern part of the metropolitan area. According to the result of observations since 1978, maximum 177cm of subsidence has already proved. The subsiding area expands to approximately 20km inland from the coast, and the subsidence doesn't appear to be ceasing judging from the trend of yearly changes.

2.6 Flood Disaster Risks in Jakarta

Major factors which cause flooding in Jakarta are (1) Land subsidence, (2) Urbanization, (3) Sea water level rise due to climate change, and (4) Increasing rainfall due to climate change, as illustrated in Figure- 2.6.1.

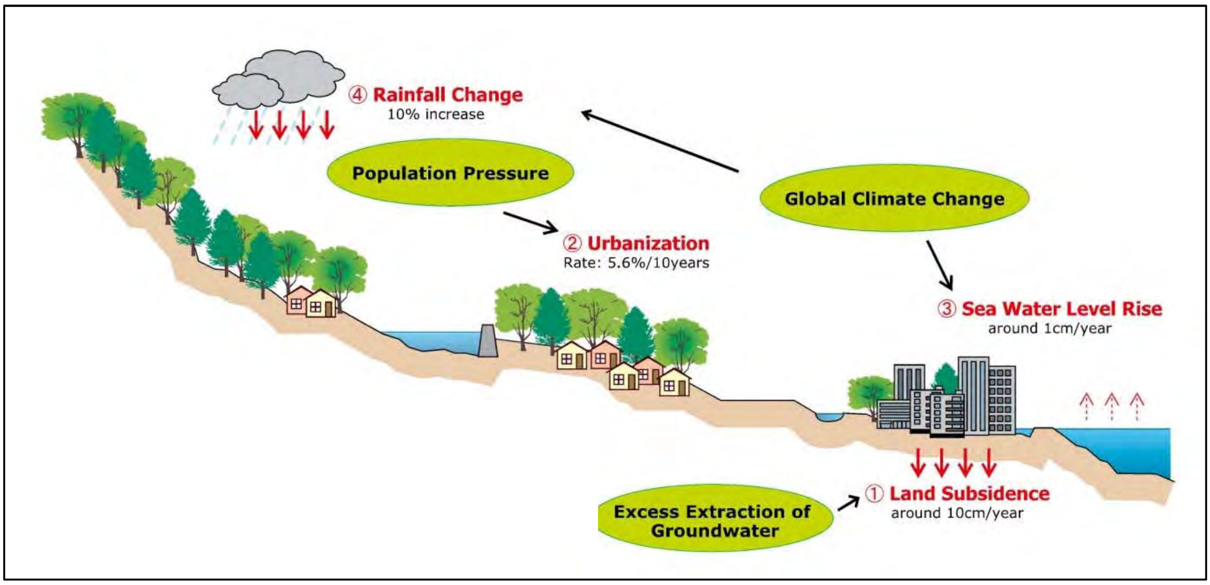


Figure- 2.6.1 Flood Disaster Risks in Jakarta

2.7 Socio-Economic Condition

2.7.1 Administration/Role and Function of DKI Jakarta

DKI Jakarta is divided administratively into five municipalities (Kota) and one regency (Kabupaten)[1]. They are Kota Jakarta Selatan (South Jakarta), Kota Jakarta Timur (East Jakarta), Kota Jakarta Pusat (Central Jakarta), Kota Jakarta Barat (West Jakarta), Kota Jakarta Utara (North Jakarta) and Kepulauan Seribu (Seribu Islands). These municipalities and the regency have 44 districts (Kecamatan) and 267 villages (Kelurahan) in total.

The roles and functions of DKI Jakarta are summarized as follows (RTRW DKI Jakarta 2030):

- Capital of the nation
- Economic center
- Center for business and trade
- Main gate of Indonesia
- City tourism and socio-culture
- Core city in JABODETABEK area

[1] Municipality (Kota) is an administrative division which is set in urban area, and regency (Kabupaten) is the same in rural area. Both are at the same level on the administrative system in Indonesia.

2.7.2 Population and Households Status

The total population of DKI Jakarta has grown from 8,361 thousand in 2000 to 9,588 thousand in 2010. This translates to an average increase of approximately 1.39 percent per year. The average population density of DKI Jakarta in 2010 was 145 persons per hectares with a range of 112 persons in Jakarta Utara to 187 persons in Jakarta Pusat.

The number of households has also increased from 2,232 thousand in 2000 to 2,548 thousand in 2010. The average increase rate of households from 2000 to 2010 was estimated at approximately 1.33 percent per year.

The population of Jakarta is expected to increase by 12.5 million in 2030, according to the RTRW DKI Jakarta 2030. If population in Jakarta further increases up to 2050 as high as ever or even at a half of the recent increase rates, it is likely to increase in a range of approximately 14 – 16 million by 2050 (estimation by JICA Study Team).

2.7.3 Land Use Condition

In 2007, most of the land in Jakarta is used for residential purpose (approximately 53 percent) and commercial and industrial purposes (approximately 16 percent). It is distinguished in Jakarta that manufacturing activities are mostly occurred in Jakarta Utara and Jakarta Timur, while business and office administration are widely developed in Jakarta Barat, Jakarta Pusat and Jakarta Selatan

2.7.4 Economic Factor

(1) Economic Growth

The overall trend of GDP annual growth in Indonesia has been still steadily positive over the years since 2005. According to the Statistical Yearbook of Indonesia 2010, the average growth rate of Indonesia in the period of 2006-2009 reached approximately 5.6 percent per year

The average growth rate of DKI Jakarta from 2006 to 2009 has also grown by 5.8 percent per year which is a little bit higher compared to the national average.

(2) Economic Structure by Industrial Origin

In the formation of real GRDP by main industrial origin in 2009, financial sector was the largest contribution of 29.4 percent, followed by trade/hotel/restaurant sector (21.7 percent) and manufacturing sector (16.5 percent).

(3) GRDP by Municipality

GRDP by regency/municipality in 2009, Jakarta Pusat had the highest contribution of 26 percent of the total GRDP, followed by Jakarta Selatan (23 percent), Jakarta Utara (19 percent), and Jakarta Timur (17 percent). The least contributing was Jakarta Barat (15 percent) except Kep. Seribu (less than 1 percent).

(4) Employment Status

In 2009, approximately 4,188 thousand people or 88 percent of the total economically active were employed. The rest 569 thousand people or 12 percent of the total economically active were not employed. In addition, approximately 37 percent of the employed worked in trade/hotel/restaurant sector. It was followed by services sector (24 percent), manufacturing sector (16 percent) and transportation/communication sector (10 percent).

(5) Future Economic Growth (National Overview)

The 2010-2014 National Medium-Term Development Plan (RPJMN 2010-2014)[2] reveals that in the period of 2010 – 2014, Indonesian economy is expected to gradually grow from 5.5-5.6 percent in

[2] The second phase of implementation of the 2005-2015 National Long-Term Development Plan (RPJPN 2005-2015)

2010 to 7.0-7.7 percent in 2014, at the average growth rate of 6.3-6.8 percent per year over the next five years.

2.8 Infrastructure Condition

2.8.1 Road Network

The main transportation modes for the people in Jakarta and its suburbs are road transportation such as private cars and buses, and rail transportation. Traffic volume which exceeds the capacity of road infrastructure as a direct factor and concentration of economic activities in Jakarta and its surrounding municipalities (JABODETABEK) as an indirect factor result in serious traffic congestion problems on several main roads and critical crossings, particularly in the central business districts and causes adverse effects on regional economy.

2.8.2 Railway Network

Nowadays, railway network in JABODETABEK comprises approximately 160km of electric double lane track. The number of commuter railways in the period of 2005-2009 has increased and reached about 157 million passengers in 2009. In view of passengers' destinations, approximately 130 million passenger or 83 percent of the total passengers were the inter-provincial passengers within JABODETABEK in 2009.

2.8.3 Bus Way Network

Rapid bus services with two-lane road dedicated for exclusive public and mass transportation service that runs over the principal trunk roads in Jakarta are managed and operated by PT. Trans Jakarta. The number of passengers has increased year by year and reached approximately 82 million passengers a year or more than 200 thousand passengers a day on the average in 2009.

2.8.4 Electricity

The number of PLN customers has steadily increased in line with the increasing demand for electricity. The total number of customer in 2009 was 3,572 thousand. By customers' composition, the largest group was household category which was 3,246 thousand accounting for about 91 percent of the total customers.

2.8.5 Water Supply

The number of PDAM (Water Supply Company) customers increased continuously in accordance with the awareness of people to consume clean water brought by the spread of public water supply network. The total number of customers in 2009 was 795,149 customers.

2.8.6 Solid Waste Management Facilities

People of DKI Jakarta produced around 28,286m^3 of garbage every day in 2009. About 55.4 percent of them were organic disposal which comes from organic material (i.e., leftover from meal, etc.) and the rest 44.6 percent comes from non-organic.

2.9 Provincial Spatial Plan of DKI Jakarta (RTRW DKI Jakarta 2030)

The current provincial spatial plan of DKI Jakarta to cover the period from 2011 to 2030 (RTRW DKI Jakarta 2030) has been approved by the parliament in August 2011. RTRW DKI Jakarta 2030 provides for a number of significant policies and strategies for Space Structure and Space Pattern.

These policies and strategies must be well-integrated into future urban, sectoral and infrastructure plan including flood control plan etc.in order to successfully achieve the goal as stipulated in RTRW DKI Jakarta 2030.

CHAPTER 3 Inundation Areas and Damage Level Estimation

3.1 Climate Change Scenarios and Simulation Conditions

3.1.1 Building the Climate Change Scenarios

Climate change scenarios were built in order to estimate the increase in rainfall and sea level rise in 2050. Following climate change scenarios were settled based on social and economic changes described in IPCC 4th assessment report. In this study, just as the examination cases in Manila and Bangkok, climate change condition in 2050 was simulated by following two scenarios (see Table-3.1.1).

・A1F1 scenarios: high growth society scenario valuing on the fossil energy source
・B1 scenarios: sustainable development scenario

Table- 3.1.1 Climate Change Scenarios

Scenario※		Application			
		Manila	Bangkok	Ho Chi Minh	**Jakarta**
A1	Growth-oriented Society Scenario				
A1FI	Value on Fossil Energy Resources	●	●	—	●
A1T	Value on Nonfossil Energy Resources	—	—	—	—
A1B	Value on Balance of Energy Resources	—	—	—	—
A2	Pluralistic Society Scenario	—	—	●	—
B1	Sustainable Development Society Scenario	●	●	—	●
B2	Community Coexistence Scenario	—	—	●	—

※Social and economic changes in IPCC 4th assessment report

3.1.2 Estimation of Climate Change in 2050

(1) Estimation of Rainfall Increment in 2050

Rainfall increment in 2050 was estimated in accordance with downscaling procedure implement the downscaling in this Study. As a result, rainfall increment in 2050 was estimated at 17 percent in A1FI Scenario, and 8 percent in B1 scenario.

(2) Estimation of Sea Level Rise in 2050

Sea level rise in 2050 was estimated as shown in Table- 3.1.2 considering observation data and estimation inferred from global model.

Table- 3.1.2 Sea Level Rise in 2050 (cm)

Scenario	Observation data	Global model	Adopted value
P	-	0 cm	0 cm
B1	-	19 cm	20 cm
A1FI	39cm	29 cm	39 cm

3.1.3 Estimation of Land Use in 2050

Land use in 2050 was estimated based on the spatial plan of related municipalities in 2030 considering the uncertainty over the prediction of land development in 2050. Urbanization rate in 2050 is estimated to be 84.3 percent, 22 percent higher than that in 2008. Runoff rate in 2050 is estimated to be f = 0.79, 0.05 higher than that in 2008.

3.1.4 Estimation of Land Subsidence in 2050

The following two scenarios were employed to estimate the amount of land subsidence.

(1) Estimation of land subsidence based on the trend of previous survey data

The amount of land subsidence was from 0.7m up to 5.9m. Severe land subsidence can be seen mainly in the Cengkareng Floodway located in the northern area of West Jakarta, and in the junction area of Angke and Mookervaart Canal.

(2) Estimation of land subsidence by recent trend of subsidence

The amount of land subsidence in 2050 was estimated by the yearly average amount of subsidence calculated by an analysis of satellite image from 2007 to 2011. The amount of land subsidence is assumed to be maximum depth at 2.5m up to 2050.

3.1.5 Building the Infrastructure Scenarios

The extent of flood damage in river basin and coastal area in 2050 would depend not only on the impact of climate change but also on the capacity of flood infrastructure in DKI Jakarta. Given the above, three types of flood infrastructure scenarios described in Table- 3.1.3 were established in this Study.

Table- 3.1.3 Flood Infrastructure Scenarios

Scenario		Contents
SQ	Status Quo Scenario	The existing flood control infrastructure would be maintained by 2050; the existing flood control facilities are as of 2011.
MP	Master Plan Scenario	The flood control infrastructure in 2050 would be based on the implementation of existing Master Plan. The Ciliwung Floodway of which construction has been suspended at present was not considered in this scenario. On the other hand, Ciliwung River improvement plan to be implemented after the completion of Master Plan by the Government of Indonesia was taken into account.
MP＋PS	Master Plan + Strengthening of Pumping Station Scenario	The existing Master Plan would be strengthened with Pumping Station by 2050.

3.1.6 Climate Change Scenarios

Climate change scenarios and simulation conditions considering urbanization, increased rate of rainfall, sea level rise, high tide, and land subsidence are shown in Table- 3.1.4

Table- 3.1.4 Climate Change Scenario and Simulation Conditions

Climate Change Scenario	Temperature rise(℃) (downscaled)	Urbanization	Increased Rate of Rainfall	Sea-Level-Rise (cm)	High Tide Level (m)	Land Subsidence (m)
P	-	62.8% (2008)	0%	0	1.15	V0 = 0m V1 = 0.3m - 2.5m V2 = 0.9m – 5.9m
B1	0.8	84.3% (2050)	8%	20	1.15	V0 = 0m V1 = 0.3m - 2.5m V2 = 0.9m – 5.9m
A1F1	1.7	84.3% (2050)	17%	39	1.15	V0 = 0m V1 = 0.3m - 2.5m V2 = 0.9m – 5.9m

P: No Climate Change, B1: Sustainable Development Society Scenario, A1FI: Growth-oriented Society Scenario
V0: No Land Subsidence, Relatively Stable Subsidence, V2: Severe Land Subsidence

Consequently, climate change scenarios and flood infrastructure scenarios were combined, and a total of 45 cases of simulation was established as follows:

- Return period: 1/10, 1/30, 1/100
- Land use: P(present condition in 2008), F(future condition in 2050)
- Flood Infrastructure: SQ(status quo scenario), MP(Master Plan scenario), MP+PS(MP + Strengthening of Pumping Station)
- Climate Change: P(no climate change), B1(sustainable development society scenario), A1FI(growth-oriented society scenario/set importance on fossil energy resources)
- Land Subsidence: V0(no land subsidence relative to 2008), V1(relatively stable land subsidence), V2(severe land subsidence)

3.2 Flood Inundation Analysis Model

3.2.1 Selection of Flood Inundation Analysis Model

As shown in Figure- 3.2.1, Distributed System Model composed of Distributed Runoff Model for discharge basin and Two Dimensional Un-Steady Flow Model for inundation area was employed as flood inundation analysis model in this Study.

- Reflecting the features of the basin (topography, land use, etc.) and flooding of both inland water and external water can be simulated
- Effectiveness of various flood control measures in the basin can be evaluated.

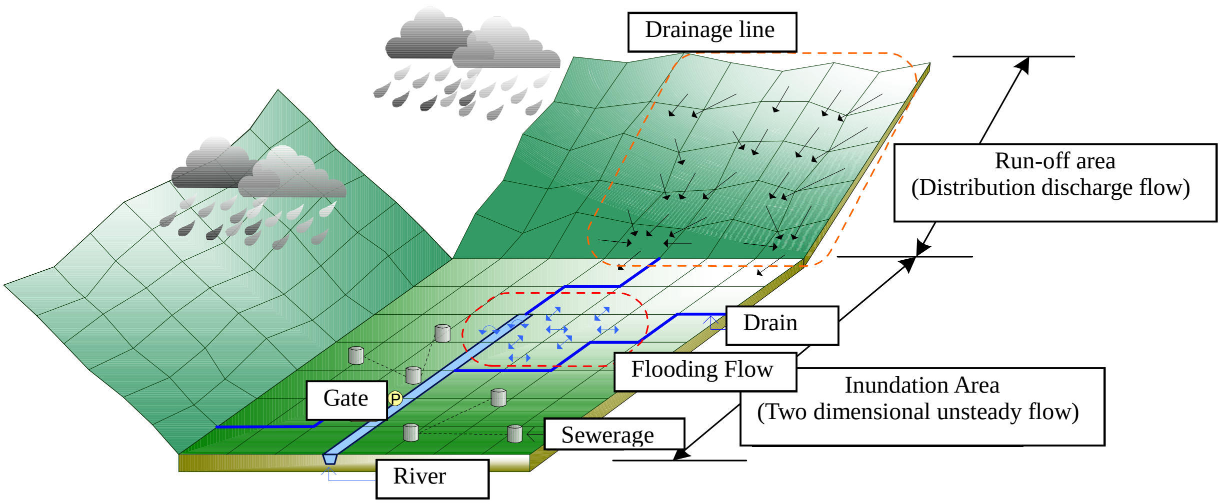


Figure- 3.2.1 Image of Flood Inundation Analysis Model

3.2.2 Basic Structure of Flood Inundation Model

Basic structure of flood inundation model considered characteristics of target river basin is as follows:

<u>Rainfall model</u>
Time series distribution of rainfall is given to overall basin with consideration of loss phenomenon.
<u>River model</u>
Forced discharge to the river and tide level at the mouth of the river is reflected in the river level and hourly fluctuation is duplicated by One Dimensional Un-Steady Flow Model which can describe the overflow and the dike break.
<u>Run-off area model</u>
Runoff volume to the run-off area fixed based on land features is duplicated by Distributed Runoff Model (Kinematic Wave) which can trace the runoff volume in accordance with actual flow channels.
<u>Inundation area model</u>
Flood propagation is traced by Distributed Runoff Model considering water channels, sewerages, drainage system from pump stations, earth fill, as well as the land features of inundation area.

3.2.3 Formulation of Flood Inundation Model

Brief summary of flood inundation model is shown in Table- 3.2.1.

Table- 3.2.1 List of Flood Inundation Analysis Model

Items		Conditions	Remarks
Analysis Model	River Inundation area Run-off area	One dimensional un-steady flow model(Dynamic Wave) Two dimensional un-steady flow model(Dynamic Wave) Distributed runoff model (Kinematic Wave)	
Land Feature	Basic mesh Inundation area land feature Run-off area land feature Land use (inundation area) Land use (run-off area)	230m(7.5”) (around 28,300 meshes) Current condition in 2008 Current condition in 2008 Current condition in 2008 Current condition in 2009	1/5000 Topographic map and GPS data 1/25000 Topographic map DKI land use map Jabodetabekpunjur land use map
River /Facilities	River Drainage canals Pimps Gates Others	Current condition in 2011 Current condition in 2011 Current condition in 2011 Current condition in 2011 -	Secondary affluent
Rainfall	Waveform	Flood in Feb. 2007	provided dimensionally by Thiessen method

3.3 Inundation Areas and Damage Level Estimation

3.3.1 Climate Change Scenarios and Flood Infrastructure Scenarios

Table- 3.3.1 shows simulation cases in 1-in-10-year flood as examples.

Table- 3.3.1 Simulation Cases (Climate Change Scenarios and Flood Infrastructure Scenarios)

NO	Return Period	Year	Land Use	Infrastructure	Climate Change	Land Subsidence	Scenarios
1	10	2008	P	SQ	P	V0	2008_P_SQ_P_v0_10
2	10	2050	P	MP	P	V0	2050_P_MP_P_v0_10
3	10	2050	F	MP	P	V0	2050_F_MP_P_v0_10
4	10	2050	F	MP	B1	V0	2050_F_MP_B1_v0_10
5	10	2050	F	MP	B1	V1	2050_F_MP_B1_v1_10
6	10	2050	F	MP	B1	V2	2050_F_MP_B1_v2_10
7	10	2050	F	MP	A1FI	V0	2050_F_MP_A1FI_v0_10
8	10	2050	F	MP	A1FI	V1	2050_F_MP_ A1FI _v1_10
9	10	2050	F	MP	A1FI	V2	2050_F_MP_ A1FI _v2_10
10	10	2050	F	MP+PS	B1	V0	2050_F_MP+PS_B1_v0_10
11	10	2050	F	MP+PS	B1	V1	2050_F_MP+PS _B1_v1_10
12	10	2050	F	MP+PS	B1	V2	2050_F_MP+PS _B1_v2_10
13	10	2050	F	MP+PS	A1FI	V0	2050_F_MP+PS _A1FI_v0_10
14	10	2050	F	MP+PS	A1FI	V1	2050_F_MP+PS _ A1FI _v1_10
15	10	2050	F	MP+PS	A1FI	V2	2050_F_MP+PS _ A1FI _v2_10

3.3.2 Flood Inundation Damage Area/Volume/Average Depth

Table- 3.3.2 presents the inundation area/inundation volume/average depth obtained from simulation.

Table- 3.3.2 Results of Inundation Simulation

NO	Return Period	Year	Land Use	Infra-structure	Climate Change	Land Subsidence	Inundation Area (km2)	Ratio for Inundation Area	Area Ratio for No.1	Inundation Volume (millionm^3)	Volume ratio for No.1	Average Inundation Depth (m)
1	10	2008	P	SQ	P	V0	237.9	39%	100%	154.9	100%	0.65
2	10	2050	P	MP	P	V0	231.6	38%	97%	142.0	92%	0.61
3	10	2050	F	MP	P	V0	233.9	38%	98%	150.7	97%	0.64
4	10	2050	F	MP	B1	V0	253.3	41%	106%	180.4	116%	0.71
5	10	2050	F	MP	B1	V1	300.4	49%	126%	276.4	178%	0.92
6	10	2050	F	MP	B1	V2	310.9	51%	131%	355.0	229%	1.14
7	10	2050	F	MP	A1FI	V0	264.2	43%	111%	197.2	127%	0.75
8	10	2050	F	MP	A1FI	V1	308.1	50%	130%	295.8	191%	0.96
9	10	2050	F	MP	A1FI	V2	320.6	52%	135%	382.5	247%	1.19
10	10	2050	F	MP+PS	B1	V0	248.0	41%	104%	165.4	107%	0.67
11	10	2050	F	MP+PS	B1	V1	279.0	46%	117%	212.8	137%	0.76
12	10	2050	F	MP+PS	B1	V2	283.7	46%	119%	224.9	145%	0.79
13	10	2050	F	MP+PS	A1FI	V0	258.0	42%	108%	179.9	116%	0.70
14	10	2050	F	MP+PS	A1FI	V1	288.5	47%	121%	230.7	149%	0.80
15	10	2050	F	MP+PS	A1FI	V2	294.2	48%	124%	246.7	159%	0.84
16	30	2008	P	SQ	P	V0	241.9	40%	102%	161.3	104%	0.67
17	30	2050	P	MP	P	V0	235.0	38%	99%	144.7	93%	0.62
18	30	2050	F	MP	P	V0	237.4	39%	100%	154.0	99%	0.65
19	30	2050	F	MP	B1	V0	257.4	42%	108%	183.9	119%	0.71
20	30	2050	F	MP	B1	V1	303.8	50%	128%	283.2	183%	0.93
21	30	2050	F	MP	B1	V2	315.3	52%	133%	365.3	236%	1.16
22	30	2050	F	MP	A1FI	V0	268.9	44%	113%	201.5	130%	0.75
23	30	2050	F	MP	A1FI	V1	312.1	51%	131%	303.9	196%	0.97
24	30	2050	F	MP	A1FI	V2	324.3	53%	136%	394.2	254%	1.22
25	30	2050	F	MP+PS	B1	V0	252.5	41%	106%	169.3	109%	0.67
26	30	2050	F	MP+PS	B1	V1	282.4	46%	119%	218.6	141%	0.77
27	30	2050	F	MP+PS	B1	V2	287.6	47%	121%	232.1	150%	0.81
28	30	2050	F	MP+PS	A1FI	V0	263.1	43%	111%	185.3	120%	0.70
29	30	2050	F	MP+PS	A1FI	V1	292.5	48%	123%	238.1	154%	0.81
30	30	2050	F	MP+PS	A1FI	V2	298.1	49%	125%	255.7	165%	0.86
31	100	2008	P	SQ	P	V0	247.2	40%	104%	169.8	110%	0.69
32	100	2050	P	MP	P	V0	239.8	39%	101%	148.8	96%	0.62
33	100	2050	F	MP	P	V0	243.4	40%	102%	159.7	103%	0.66
34	100	2050	F	MP	B1	V0	264.0	43%	111%	190.0	123%	0.72
35	100	2050	F	MP	B1	V1	309.2	51%	130%	292.7	189%	0.95
36	100	2050	F	MP	B1	V2	321.6	53%	135%	378.3	244%	1.18
37	100	2050	F	MP	A1FI	V0	277.1	45%	116%	210.0	136%	0.76
38	100	2050	F	MP	A1FI	V1	317.3	52%	133%	314.3	203%	0.99
39	100	2050	F	MP	A1FI	V2	331.2	54%	139%	410.5	265%	1.24
40	100	2050	F	MP+PS	B1	V0	258.8	42%	109%	175.9	114%	0.68
41	100	2050	F	MP+PS	B1	V1	287.9	47%	121%	227.2	147%	0.79
42	100	2050	F	MP+PS	B1	V2	293.4	48%	123%	243.2	157%	0.83
43	100	2050	F	MP+PS	A1FI	V0	269.7	44%	113%	194.1	125%	0.72
44	100	2050	F	MP+PS	A1FI	V1	299.0	49%	126%	248.0	160%	0.83
45	100	2050	F	MP+PS	A1FI	V2	304.4	50%	128%	268.5	173%	0.88

3.3.3 Findings from Inundation Analysis

(1) Impact of Urbanization

Due to urbanization, inundation area is increased about 1 percent, whereas, inundation volume is increased about 7 percent, and average inundation depth is increased about 6 percent (see Table-3.3.3).

Table- 3.3.3 Impact of Urbanization

Case Name	(A) 2050_P_MP_P_v0_100	(B) 2050_F_MP_P_v0_100
Flood Area	239.8 km^2 (100%)	243.4 km^2 (101%)
Flood Volume	$148.8\times10^6 m^3$ (100%)	$159.7\times10^6 m^3$ (107%)
Flood Depth	0.62m (100%)	0.66m (106%)

(2) Impact of Climate Change

Due to climate change, inundation area is increased about 8-14 percent, inundation volume is increased about 19-31 percent, and average inundation depth is increased about 10-15 percent (see Table- 3.3.4).

Table- 3.3.4 Impact of Climate Change

Case Name	(A) 2050_F_MP_P_v0_100	(B) 2050_F_MP_B1_v0_100	(C) 2050_F_MP_A1FI_v0_100
Flood Area	243.4 km^2 (100%)	264.0 km^2 (108%)	277.1 km^2 (114%)
Flood Volume	$159.7\times10^6 m^3$ (100%)	$190.0\times10^6 m^3$ (119%)	$210.0\times10^6 m^3$ (131%)
Flood Depth	0.66m (100%)	0.72m (110%)	0.76m (115%)

(3) Impact of Land Subsidence

Due to land subsidence, inundation area is increased about 15-20 percent, inundation volume is increased about 50-95 percent, and average inundation depth is increased about 31-64 percent (see Table- 3.3.5).

As shown in Figure- 3.3.1, the impact of land subsidence is greater than the impact of climate change.

Table- 3.3.5 Impact of Land Subsidence

Case Name	(A) 2050_F_MP_A1FI_v0_100	(B) 2050_F_MP_A1FI_v1_100	(C) 2050_F_MP_A1FI_v2_100
Flood Area	277.1 km^2 (100%)	317.3 km^2 (115%)	331.2 km^2 (120%)
Flood Volume	$210.0\times10^6 m^3$ (100%)	$314.3\times10^6 m^3$ (150%)	$410.5\times10^6 m^3$ (195%)
Flood Depth	0.76m (100%)	0.99m (131%)	1.24m (164%)

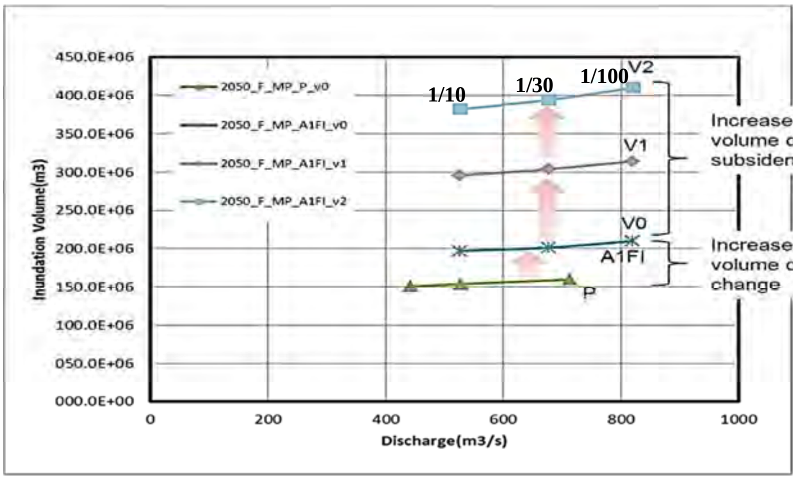


Figure- 3.3.1 Change of Inundation Volume by the Amount of Land Subsidence

(4) Effect of Pump Stations

By increasing the capacity of pump stations, inundation area is decreased about 8 percent, inundation volume is decreased about 35 percent, and the average inundation depth is decreased about 29 percent (see Table- 3.3.6 and Figure- 3.3.2).

Table- 3.3.6 Effect of Pump Stations

Case Name	(A) 2050_F_MP_A1FI_v2_100	(B) 2050_F_MP+PS_A1FI_v2_100
Flood Area	331.2 km^2 (100%)	304.4 km^2 (92%)
Flood Volume	$410.5\times10^6 m^3$ (100%)	$268.5\times10^6 m^3$ (65%)
Flood Depth	1.24m (100%)	0.88m (71%)

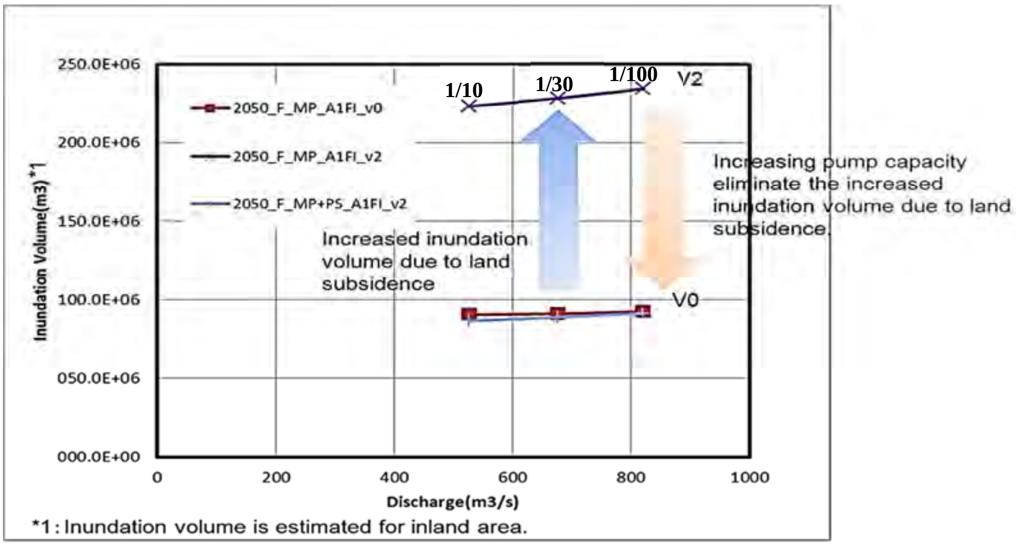


Figure- 3.3.2 Change of Inundation Volume by Increasing Pump Capacity

CHAPTER 4 Impact Analysis on Socio-Economy

4.1 Methodology to Assess Damage Costs

4.1.1 Setting-Up Scenarios

Flood Damage costs were assessed with 45 scenarios. In each scenario, flood damage costs were estimated with different return period (flood intensity) – such as 1-in-10-year flood (1/10), 1-in-30-year flood (1/30) and 1-in-100-year flood (1/100).

4.1.2 Direct and Indirect Damages Caused by Floods

Following direct and indirect impacts associated with flooding were identified in terms of damage costs:

【Direct Damages】

- Damages to buildings (residential, commercial and industrial buildings)
- Damage to assets and inventories (residential, commercial and industrial buildings)
- Damage to infrastructure (road and public services including urban sanitation)

【Indirect Damages】

- Income losses (commercial and industrial units)
- Losses of revenue (electricity and water supply companies)

4.1.3 Assumptions for Estimating Damage Costs

This Study made several assumptions for estimating damage costs by 2050. Among others, it is important to note the following assumptions:

- The damage costs in 2050 are estimated basically based on the socio-economic conditions and prices in 2008;
- Similarly, in terms of GRDP, all damage costs are represented in Indonesian Rupiahs (Rp) in 2008, thus to estimate percent of GRDP, current 2008 GRDP[3] were used;
- Basic data concerning assets, value and prices etc. were based on available statistical data obtained from the Indonesian authorities such as Badan Pusat Statistik Republik Indonesia (BPS), Bandan Pusat Statistik Provinsi DKI Jakarta etc. These data were supplemented and adjusted with information from relevant projects, studies and the consultants; and
- Since there was no proper benchmark to estimate flood damage in Indonesia, damage coefficient and rates revealed in “Manual of Economic Study of Floods”, MLIT of Japan[4] listed in Appendix of the report were applied, where available, for the assessment of damage costs.

4.1.4 Assessment of Damage Costs by Sector

(1) Damage to Buildings

Buildings were categorized (residential, commercial and industrial), counted and valuated on average based on available government data by categories of building. Different damage coefficient depending on the level (depth) of the flood was then applied to estimate damage costs from floods for each category of building.

(2) Damage to Assets and Inventories

Household assets were valued by categories of residential buildings based on available government data, i.e., permanent and non-permanent houses. Assets and inventories of commercial and industrial units such as machinery, office furniture, and inventories damaged by floods were also estimated. Value of assets and inventories of commercial and industrial units was based on the data from BPS Provinsi DKI Jakarta and so on.

[3] GRDP of DKI Jakarta in 2008: Rp 677,411 Billion
[4] Ministry of Land, Infrastructure and Transportation of Japan

(3) Damage to Infrastructure

In estimating the damage costs to infrastructure, when considered on the basis of damage rate of infrastructure which was read off as a percentage to the sum of the damage costs of buildings and assets, the percentage of damage to transport infrastructure was assumed at 13 percent of the sum of the damage costs of buildings and assets.

Including damages to other infrastructure, the total damage rate of infrastructure were assumed to be 22 percent of the sum of the damage costs of buildings and assets, and this rate is a relatively restricted compared to the rate employed in Japan by the MLIT of Japan

(4) Indirect Damages from Floods

Indirect damage from floods will generally be extended widely. There are also tangible and in-tangible costs associated with flooding, for instance, damage costs to transport sector such as time costs caused by traffic disruption and increase in vehicle operating cost. As a result, this Study examined only the following two indirect damages resulting from a loss in the flow of goods and services to the economy.

- Loss of income of commercial and industrial units
- Revenue losses to water and electricity companies

4.2 Summary of Flood Damage Costs

Table- 4.2.1 presents the costs incurred from flood damages to buildings, assets, infrastructure, and income and revenue losses for a range of 45 different scenarios prepared for this Study.

Table- 4.2.1 Summary of Flood Damage Costs

Scenario	Return Period					
	1-in-10-year flood (1/10)		1-in-30-year flood (1/30)		1-in-100-year flood (1/100)	
	Cost (Billion Rp)	Percent to GRDP	Cost (Billion Rp)	Percent to GRDP	Cost (Billion Rp)	Percent to GRDP
2008_P_SQ_P_v0	60,759	9.0	63,183	9.3	66,498	9.8
2050_P_MP_P_v0	55,655	8.2	56,684	8.4	57,870	8.5
2050_F_MP_P_v0	56,660	8.4	57,989	8.6	60,513	8.9
2050_F_MP_B1_v0	65,783	9.7	67,119	9.9	70,288	10.4
2050_F_MP_B1_v1	100,230	14.8	103,408	15.3	107,579	15.9
2050_F_MP_B1_v2	122,838	18.1	126,527	18.7	132,051	19.5
2050_F_MP_A1FI_v0	71,076	10.5	73,229	10.8	77,218	11.4
2050_F_MP_A1FI_v1	107,243	15.3	110,696	16.3	115,716	17.1
2050_F_MP_A1FI_v2	132,372	19.5	136,812	20.2	143,786	21.2
2050_F_MP+PS_B1_v0	62,418	9.2	63,829	9.4	66,970	9.9
2050_F_MP+PS_B1_v1	78,972	11.7	81,252	12.0	84,527	12.5
2050_F_MP+PS_B1_v2	85,604	12.6	88,211	13.0	92,612	13.7
2050_F_MP+PS_A1FI_v0	67,173	9.9	69,616	10.3	73,379	10.8
2050_F_MP+PS_A1FI_v1	84,667	12.5	87,420	12.9	91,937	13.6
2050_F_MP+PS_A1FI_v2	92,977	13.7	96,388	14.2	101,809	15.0

4.3 Main Findings from Analysis

4.3.1 Substantial Flood Damage Costs in 2050

A comparison across scenarios shows the minimum and the maximum costs associated with flooding as follows: Damage cost for **2050_F_MP_P_v0** in 1-in-10-year flood where there is no climate change nor land subsidence was estimated to result in Rp 56,660 Billion and showed the minimum damage. In terms of GRDP, this would constitute about 8.4 percent of the current 2008 GRDP of DKI Jakarta.

Whereas, under the assumption of severe land subsidence and A1FI climate scenario (high emission case), namely **2050_F_MP_A1FI_v2** in 1-in-100-year flood, the damage costs was estimated to increase remarkably and amounted to Rp 143,786 Billion, which was approximately 2.5 times as high as **2050_F_MP_P_v0** in 1-in-10-year flood and revealed the maximum damages with approximately 21.2 percent of the 2008 GRDP.

4.3.2 Impact to Increase Flood Damage Costs by Factor

Impact of each factor in increase of damage costs is explanatory by looking at a difference of damage costs with different scenarios. For instance, in 1-in-30-year flood which is a medium-sized flood event, the difference of damage costs between **2050_F_MP_A1FI_v0** and **2050_F_MP_A1FI_v2** was Rp 63,583 Billion (see Figure- 4.3.1). This difference represents the increased damage costs due to land subsidence.

Consequently, of the total increase identified as a difference in damage costs between **2050_P_MP_P_V0_30** and **2050_F_MP_A1FI_V2_30**, 79 percent is attributable to land subsidence; it dominates the major factor of increased damage costs. Impact of climate change and land use in increased damage costs were estimated to constitute approximately 19 percent and 2 percent respectively.

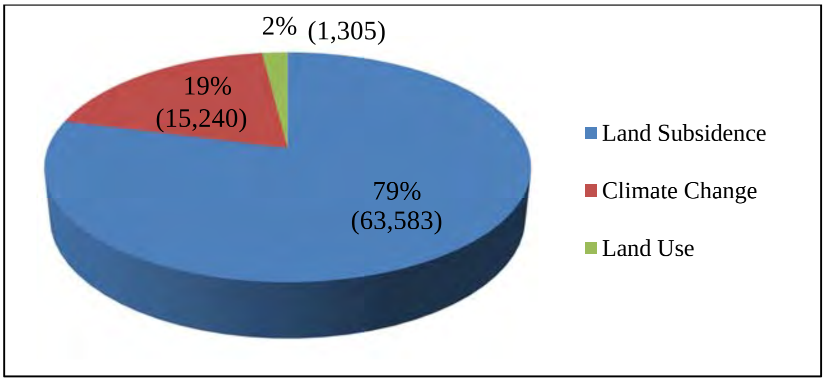


Figure- 4.3.1 Amounts and Percentage of Increased Flood Damage Cost by Factor (Billion Rp)

4.3.3 Flood Damage Costs by Damage Sector

In the context of the scenario **2050_F_MP_A1FI_v0_30**, the direct damage costs to buildings (residential, commercial and industrial buildings) including the physical damage to assets and inventories were estimated at Rp 54,513 Billion (see Table- 4.3.1). This would constitute about 74 percent of the total damage costs. It was a dominant sector of damage from flooding.

Table- 4.3.1 Damage Costs by Damage Sector in Billion Rp (2050_F_MP_A1FI_v0_30)

Damage Item	Direct Damage	Indirect Damage	Total Damage	%
Residence	28,685		28,685	39.2%
Commerce	17,261	4,699	21,960	30.0%
Industry	8,567	1,759	10,326	14.1%
Infrastructure	12,044		12,044	16.4%
Public Services		214	214	0.3%
Total	66,558	6,672	73,230	100.0%
%	91%	9%	100%	

4.3.4 Damage Costs “With” and ”Without” Pumping Stations Project

Reduction in damage costs expected from implementation of PS project was identified as the differences of damage costs between the scenarios with PS (MP + PS) and without PS (MP only). The result of estimations indicates that in every scenario where PS project was assumed, it was estimated to reduce by approximately 30 percent of flood damages.

4.3.5 Expected Average Annual Damage Cost

Figure- 4.3.2 illustrates total flood damage costs for different scenarios against the probability of flood occurrence, such as **2008_P_SQ_P_v0**, **2050_F_MP_A1FI_v2** and **2050_F_MP+PS_A1FI_v2**.

In economic point of view, the difference in flood damage costs are identified as the expected annual average reduction in flood damage costs or the average annual benefits of having flood control or damage mitigation projects like MP and MP+PS in different return period. It is important to understand that as shown in the said figure, flood damage costs increase for higher intensity of floods (1/100), while, there is a little possibility of such bigger floods occurring.

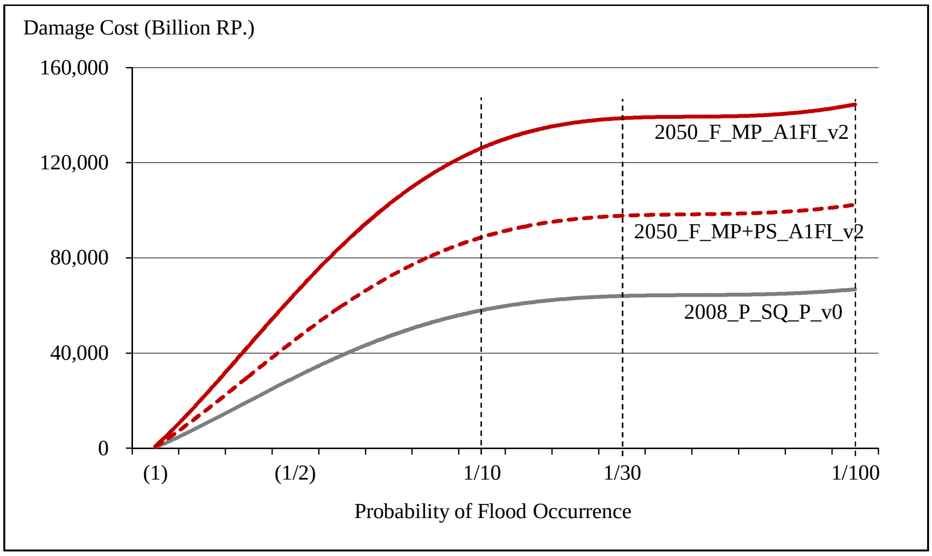


Figure- 4.3.2 Loss Exceedance Curves

4.3.6 Economic Viability of Implementation of MP Project

Economic viability of the investment for PS Project was briefly examined based on the some assumptions as stated below including expected average annual benefit (reduction in flood damage costs).

- Expected Average Annual Benefit: US$ 331 Million (Rp 3,622 Billion)[5]
- Investment Costs: US$1,875 Million (US$ 2.47 Million/m^3/sec, 760 m^3/sec) (based on construction cost of pumping station estimated by JICA Study Team)
- Period of Analysis: 37 years (2014-2050), of which the first 5 years are for construction works (2014-2018), and the first benefits are estimated in 2015, and increase gradually according to the progress of the construction works.
- Discount rate: 12 percent (commonly used as a standard discount rate for public investment in Indonesia)

The result of examination revealed that PS project would be economically feasible in terms of reducing flood damages as it provides B/C ratio of 1.38 under the 12 percent discount rate.

4.3.7 Districts Vulnerable to Flooding

In district-wise, it is evident from result of flood simulation analysis that the downstream area of the Cengkareng Channel in the northwest of Jakarta (Jakarta Barat) and a part of Jakarta Utara and Jakarta Timur, including the coastal area of the Jakarta Bay, will have the extreme damages for the **2050_F_MP_A1FI_v2_30** scenario (see Figure- 4.3.3 and Figure- 4.3.4).

[5] Exchange rate: US$1=Rp10,942

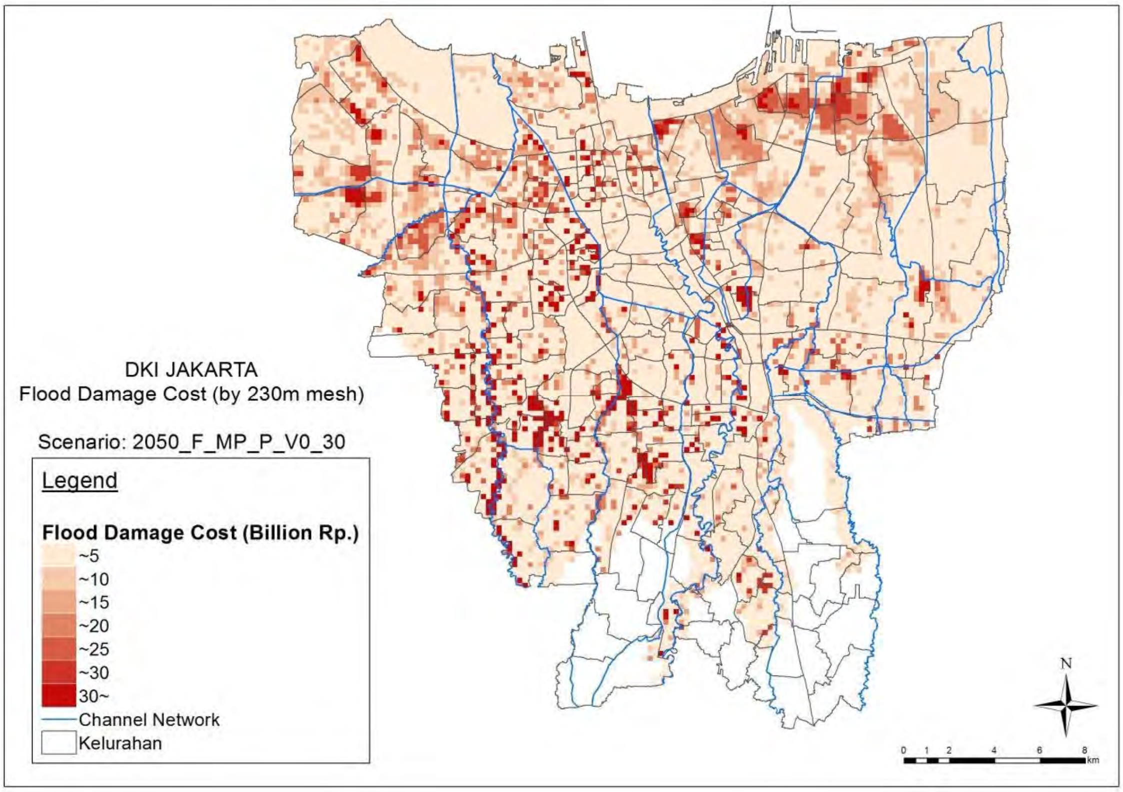


Figure- 4.3.3 Flood Damage Cost by 230m mesh (Scenario 2050_F_MP_P_v0_30)

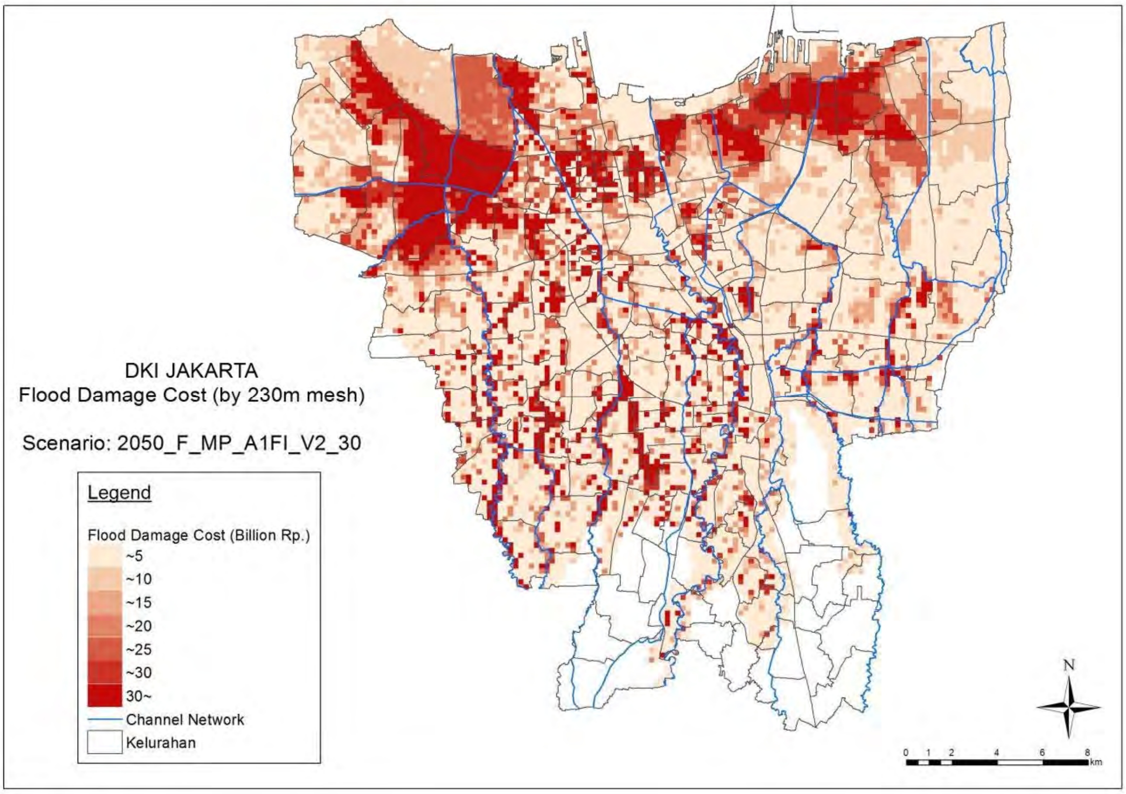


Figure- 4.3.4 Flood Damage Cost by 230m mesh (Scenario 2050_F_MP_A1FI_v2_30)

CHAPTER 5 Impact Analysis on the Urban Poor

5.1 Background and Objective

In 2002 and 2007, flood hit Jakarta and severely inundated the coastal area due to rainfall and high tide. Though the government of Jakarta has built some flood infrastructures in the shore and river line, there are still vast of areas where people's livings are suffering from inundation due to floods. Therefore, it is significant to investigate the experiences of the poor in dealing with the flood events including their impacts in Jakarta.

The main objective of the survey is to identify the impact of flood inundation on the poor in Jakarta. The survey will be conducted along with the following aims:

- To identify the living status and the environment of the poverty group in Jakarta;
- To assess the direct effects of inundations on the poverty group;
- To identify the secondary and tertiary impacts of inundation on the poverty group; and
- To specify the direct factors of the secondary and tertiary impacts of inundation on the poverty group.

5.2 Methodology

Multi-stage sampling was employed to select 15 Kelurahans shown in Figure- 5.2.1 considering slum levels and types of inundation in each Kelurahan. This household survey examined 300 samples of poor household in slum and inundation area in Jakarta. A quota sample was distributed among selected Kelurahans that are 20 samples of household in each.

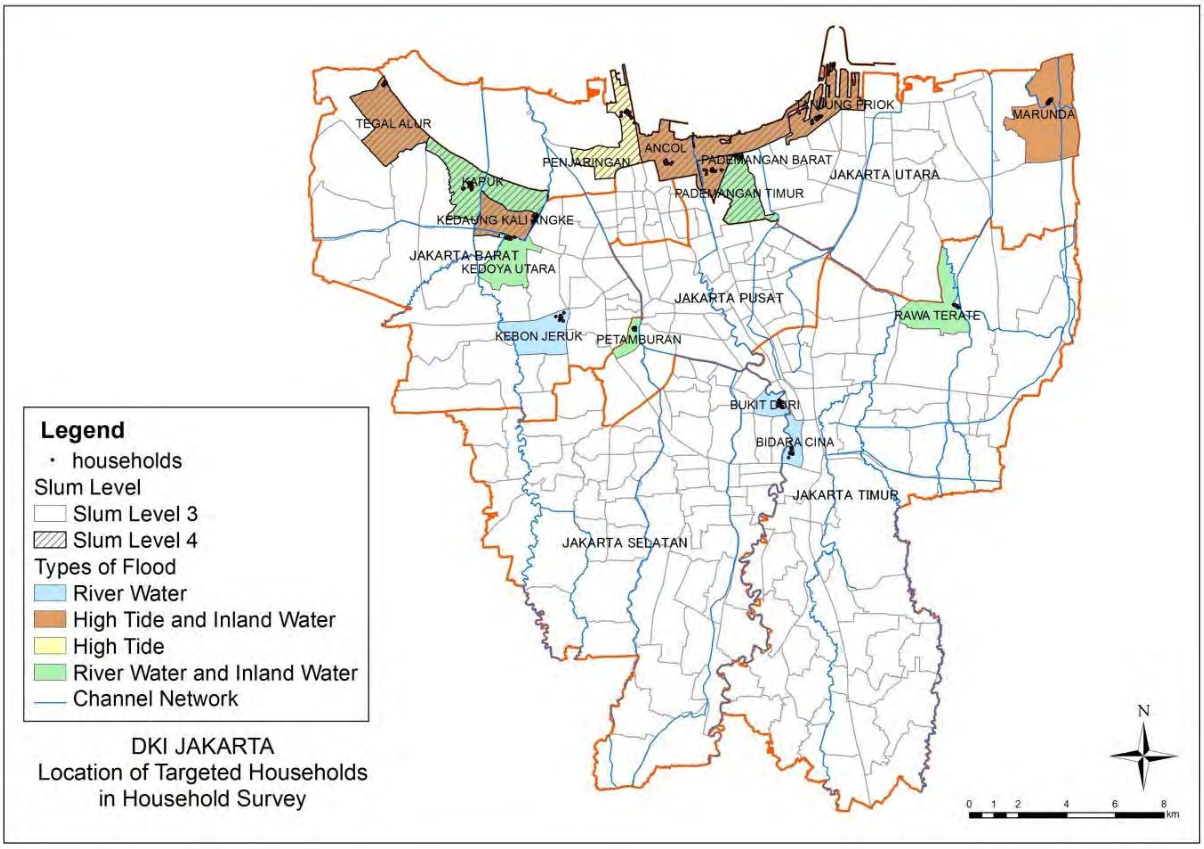


Figure- 5.2.1 Location of Survey Sites

5.3 Results

5.3.1 Survey Sites

Survey areas belong to the neighborhood scale which is called *Rukun Tetangga* (RT), the smallest neighborhood unit in Jakarta. 15 RTs were selected based on the condition of Kelurahans affected by floods and dominated by poor households in DKI Jakarta province. They spread diversely in entire Jakarta but are mostly located in north Jakarta as shown in Figure- 5.2.1 above.

5.3.2 Physical and Socio-Economic Condition

Main points are summarized as stated below:

Settlement Status: 31 percent of households occupy a house with an area of less than 19m^2 by 1-5 people, and 21 percent of them occupy an area of less than 19m^2 by more than 5 people.
Financial Status: 57.1 percent of respondents have monthly income of Rp. 500,000 or less, and 43.7 percent of them have monthly income above Rp. 500,000 to 1,000,000. (Regional minimum labor wage in Jakarta in 2011 is Rp 1,200,000.).
Housing Structure: 49 percent of households still live in a house which is not terraced nor has storage, and 44.3 percent of them live in single-story house. Wall is generally made by brick (55 percent) and the rest 22 percent made by mortar, and 12 percent made by wood.
Clean Water: There are four main sources: bottled water (37 percent), pipe water (32 percent of respondents), water from encircling water sellers (21 percent), and drilled water (10 percent).
Sanitation: 42 percent of household members go to own toilet with septic tank and 33.3 percent of them go to public toilet.

5.3.3 Experiences with Inundations

Scale of flood, both inside the house and in the street is illustrated in Figure- 5.3.1. Regarding the duration of flood, 25.6 percent of respondents stated that the inundation lasted for less than 6 hours and only 4.7 percent of them stated that it lasted for a month at their settlement. Inside the house, 53.4 percent of them said that the maximum height of water due to the inundation occurred in the past 12 months was under the ankle and 37.8 percent of them said that it was under the hip (0.2~0.5m).

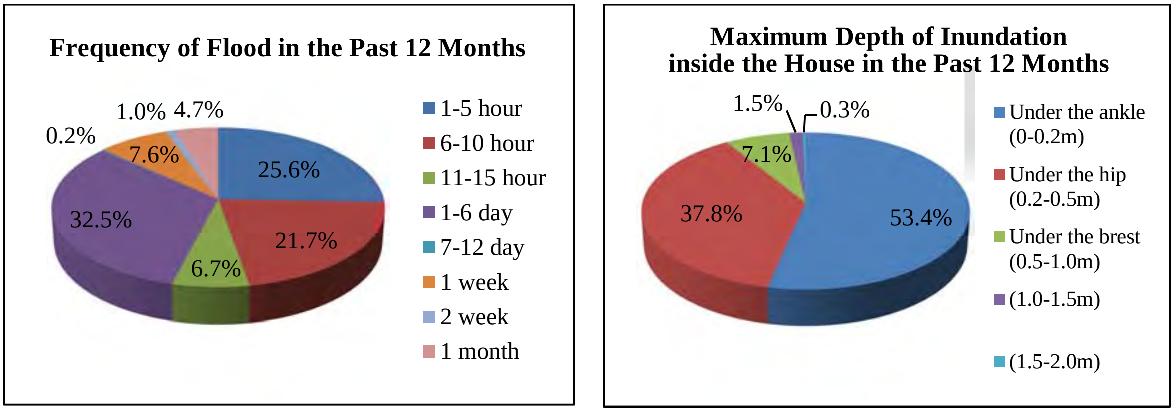


Figure- 5.3.1 Scale of Flood

5.3.4 Defining Vulnerability of the Poor in Jakarta

Living Environment: 88 percent of respondents are aware that they live in one of the inundation prone area, but they are still obliged to choose to live and stay at the inundation prone area.
Settlement: the average number of household members who live in each house is 5 persons; meanwhile the area of house is only 19 m^2. If a house is denser, it will be more vulnerable against the adverse impact of disaster for people inside.
Health Insurance: 98.3 percent of respondents have no insurance. In addition, only 9 percent of the household members are JAMKESMAS beneficiaries, and the rest have never been.
Availability of Savings: 96 percent of the respondents do not have savings. The rest 4 percent have savings in range from Rp.600.000 to 1.000.000.

CHAPTER 6 Conclusions and Recommendations

6.1 Conclusions

6.1.1 Conclusions from Flood Simulation Analysis

From the result of flood simulation analysis, it is found that;

- Analyzing its rainfall, inundation, topography, and the state of flood infrastructure, Jakarta is prone to floods especially due to inner water.
- It is found that land subsidence is in progress in Jakarta, which causes floods due to inner water because inundation water accumulated in urban area is not properly discharged to the sea. Therefore, the possibility that floods cause not only economic but also social damages in large scale has become extremely high.
- Increase of rainfall volume and sea level rise due to climate change would also cause flood damages due to inner water increase through the same process described above.
- Damages caused by floods can be exacerbated in line with the progress of urbanization, climate change, and land subsidence.
- Therefore, it is necessary to establish comprehensive flood management plans in Jakarta including countermeasures against climate change, land subsidence, land use regulations and improvement of river and storm drains etc., which cover the whole river basin.

6.1.2 Conclusion from Damage Cost Assessment

(1) Serious Flood Damage on Regional Economy

It was found from damage cost assessment that impact on flood disaster from climate and non-climate changes is likely to result in substantial damage in 2050. In terms of regional economy, it can range from approximately 8.4 percent (Rp56, 660 Billion) to 21.2 percent (Rp143, 786 Billion) of regional GRDP. As a result, it is concluded that climate and non-climate factors as well as infrastructure are responsible for much of the differences of flood damage costs. However, in any climate and infrastructure scenarios, Jakarta is faced with considerable potential damage from urban flooding in 2050.

(2) Significant Impact of Land Subsidence in Increasing Flood Damage Costs

One of the main findings of this Study is that flood damage cost caused by land subsidence is estimated to be larger than that by climate-related factors in comparison of climate-related factors such as increase in rainfall and sea water level rise etc. For instance, as discussed in the previous section, there is a much difference in damage costs between the one scenario where neither climate change nor land subsidence is assumed and another scenario assuming high emission (A1FI) and severe land subsidence (v2) (Rp 63,583 Billion). The primary reason for such a difference is “land subsidence”; as of the total increase, approximately 79 percent is due to land subsidence. Impacts of other factors such as climate change and land use change contribute approximately 19 percent and 2 percent of the total increase respectively.

(3) Substantial Damages to Buildings

The analysis of flood damage costs by sector revealed that damage costs vary by sector, however, approximately 74 percent (Rp54, 513 Billion in 2050_F_MP_A1FI_v0_30) are attributable to damage to building including the assets they carry. Therefore, countermeasures to mitigate damages to buildings need to be strengthened.

(4) Districts most at risk of Flooding

Another important finding from assessment of flood damage cost is that not all the districts of Jakarta are evenly affected due to flooding. As appeared in the past floods in 2002 and 2007, some areas in

Jakarta Utara, Jakarta Barat and Jakarta Timur, including the area of downstream of the Cengkareng Channel will be severely affected compared to other municipalities in 2050.

6.1.3 Conclusions from Household Survey on the Urban Poor

The poor in Jakarta are vulnerable in many ways according to their experiences in responding inundation. The vulnerability includes physical factors such as small and fragile structure of their houses and limited basic infrastructures, economic factors such as lack of savings, lack of insurance for their private assets, and low income, social factors such as high population density, low education levels, and no insurance. Therefore, these vulnerable conditions need to be addressed in order to formulate appropriate and effective policies for the poor.

It must also be noted that according to the perception of the poor households in the coastal area, inundation incident is mainly caused by rainfall and high tide. But, they also add poor local drainage as the other determinant factor. It implies that improvement of flood control infrastructure is of paramount importance.

6.2 Recommendations

6.2.1 Policy Recommendations

(1) Countermeasures against Land Subsidence

From the result of assessment of flood damage costs, it is found that the major factor to increase flood damage costs is land subsidence. This requires some countermeasures against land subsidence. It is therefore important to recommend the followings in order for reducing land subsidence caused by extraction and use of groundwater:

- Control the extraction and use of groundwater by business and industrial establishments;
- Encourage the conversion of main water sources from existing groundwater to surface water (tap water etc.), including development of alternative water resources, such as river water, re-use of wastewater and so on;
- Accelerate resettlement of business and industrial units to the suburbs of Jakarta, particularly for manufacturing enterprises located along the northern coastal area in Jakarta Utara and Jakarta Barat; and
- Support for the development of new industrial zone in the suburbs of Jakarta in cooperation with private sector

(2) Land Use Control and Guidance for Urban Plan and Flood Control Infrastructure

To ensure urban plans and flood control infrastructure plans to be prepared with proper consideration on future climate-related risks, it is necessary to execute properly the existing land use control and guidance and hence recommend as follows:

- In terms of urban plans, to reduce damage from flood due to land subsidence over the long run, it is necessary for the local government to review and revise the existing rules, regulations and other instruments concerning urban planning and land use such as zoning regulations, development permits and so on.
- In view of flood disaster risk reduction, developing Jakarta to the west–east direction where destructive force of runoff is relatively unlikelihood.
- Further, notably it is found in the flood simulation analysis, as in such urban districts extending along the downstream of Jakarta, there has been an increased runoff discharged from upper streams, and accordingly they have been at significant risks from flooding. To cope with this situation, it may require implementation of a comprehensive flood protection measure which has to be integrated into non-structural measures or approaches. This may, for example, include some measures proposed in the Project for Capacity Development of Jakarta Comprehensive Flood Management etc. - such as designation of flood-prone area or hazardous proximity, establishment of early warning system, construction of rainwater storage facilities etc.

(3) Establishment of Flood Risk Management Plan

To reduce the risk of disaster due to both regular flooding and a certain flooding beyond expectation, it is recommended that the local and central governments shall establish a Flood Management Plan based on assessment of the risk of floods, particularly, in relation to residential, commercial and industrial use. Regional flood assessment and flood risk management plan shall be prepared by local government in cooperation with central government as well as communities (district, village etc.) meet the requirements in each community and to ensure sustainable environment including infrastructure for a long period.

(4) Policy Implications to Respond to Impact of Climate Change on the Urban Poor

At central level, issues to be addressed include control of urbanization process with consistent and continuous policies, implementation of monitoring of the data on the urban poverty that is suitable to the facts, and establishment of land use mechanism in spatial management by monitoring and evaluating condition of vulnerable areas.

Whereas, at local government level, issues to be addressed include enhancement of community-led socialization and internalization of local environmental management, enactment of land use planning and zoning regulations in addition to the law enforcement of building code and land use permit, development and spatial plans taking the vulnerability and adaptation assessment into consideration, and intervention by the government in increasing the adaptive capacity of the poor.

6.2.2 Priority Action

Some specific recommendations have already been made at the previous section of this report. In this section, we conclude with highlighting the following priority actions that will be effective for the governments (local and central government) to consider adaptation measures and EA (Execution Agency) which should cope with the actions:

- Studies on status quo of extraction and use of groundwater and impacts by excessive amounts of groundwater drawing. (EA: DKI Jakarta)
- Planning, implementation and completion of alternation of water resources development other than groundwater including distribution network system (EA: DKI Jakarta)
- Intervention by the government in formulation and enactment of consistent and continuous policies and strategies that manage to relocation of business and industrial establishment, including improvement and development of adequate infrastructure and facilities associated with resettlement (energy, water, wastewater, waste management etc.). (EA: Establishment of New Industrial Parks by the Private Sector)
- Implementation of flood control infrastructure based on the existing Flood Control Master Plan 1997 proposed in the Study on Comprehensive River Water Management Plan in JABOTABEK (1995–1997), including river improvement projects and internal drainage facility projects. (EA: Director General of Water Resources (DGWR), Director General of Human Settlements (DGSH))
- Implementation of countermeasures for runoff control to cope with inadequate channel capacity, taking the proposals (under consideration) that have been taken up in the Project for Capacity Development of Jakarta Comprehensive Flood Management into consideration.
- Review and revise the existing rules, regulations and other instruments concerning land use planning and zoning regulations such as development permits, prescription of incentive and disincentive, criminal punishment and so on. (EA: Director General of Spatial Planning (DGSP), DKI Jakarta)
- For the areas prone to inundation/flooding, especially, where the risks of loss of life or assets is severe, control and manage appropriately "housing administration policy" that seek to minimize vulnerability to flood and to improve housing and working conditions in the suburbs of Jakarta. (EA: DKI Jakarta)
- Carrying out Flood Risk Assessment for Flood Risk Management Plan to be prepared based on Flood Hazard Map and Flood Risk Map. (EA: DGWR, DGSH)