Evaluation of Vulnerability against Flood Disaster in Jakarta

University of Miyazaki	
University of Miyazaki	

Student Member Member

Ikhsan Kamil Keisuke Murakami

1. Introduction

Flood becomes a serious problem in Jakarta because it always inundated large part of Jakarta and happens regularly. Since the development of Batavia or Old Jakarta City by Jan Pieters Z. Coen in 1619, the flood problem never finished until now¹⁾. The topography of Jakarta is relatively flat between 0^0 and 2^0 in the northern part and central part, meanwhile the southern part between 0^0 and 5^0 , only the southernmost of Jakarta has an altitude of about 50 m above sea level

(MSL)¹⁾. Regarding to its physical condition, there are around 40 % of total area or around 24.000 hectares is lies below sea level¹⁾. As the bay area, around 13 rivers and 2 flood canals flow through Jakarta²⁾. This condition has placed Jakarta vulnerable to the flood both caused by high rainfall intensity and tidal activities. According to the documentations, Jakarta was hit by major floods in 1699, 1714, 1854, 1918, 1942, 1996, 2002, 2003 and 2007^{1,2,3,4)} as list in Table-1. Based on this condition, the purposes of this study are to evaluate the inundated land use by flood event and to propose a vulnerability map against flood disaster.

Table-1 Historical Flood Event

Year	Effect				
1699	viliwung river floods old Batavia after Mount Salak erupts				
1714	Ciliwung river overflows after clearing forest areas in Puncak (upstream areas)				
1854	New Batavia is a meter under water, caused by the raging Ciliwung				
1918	Extensive Flood, Dutch colonial government begin work on The Western Flood Canal (West Banjir Canal)				
1942	The West Banjir Canal is completed, but Jakarta still floods				
1996	A flood sweeps through the capital, Approximately 10 people die and 5.000 hectares inundated				
2002	002 The Darthmouth Flood Observatory notes it as the largest flood in Jakarta history, 25 people die and around 18,000 Hectares inundated				
2003	East Banjir Canal is started				
2007	The most largest flood in Jakarta history around 57 die and financial lost around \$ 695 Milyon, and around 26.000 hectares inundated				

2. Flood Causes

For a number of years, there have been a lot of discussions on what could be the flood cause in Jakarta. Is it climate change? Is it high tides? Is it urbanization? Is it poor maintenance of infrastructure? Is it land subsidence? Is it reduction of mangrove areas for construction of pond or settlement? Is it informal settlements along river side? Every year during the rainy season, these discussions emerged after a flood hits the city. As a result, it was difficult for the authorities to Table-2.L 1 T T focus on certain issues to combat the flood.

Climate change to be accused as the cause of flood in Jakarta because it has influenced the rainfall intensity, change of rainfall seasonal activities and induced sea level rise⁶. Rainfall intensity on February 2002 and February 2007 was coincidence with rainy season which cause flood in Jakarta. Rainfall intensity during these flood events was higher than normal rainfall intensity.

The fast urbanization has negative impacts to Jakarta land use because by the increasing of population, it will need more space for settlement, space for office and space for other activities. Limited land availability and high

land price has caused encroachment of riverbank or green area for settlement. During 12 years from 1989 to 2001 there were around 18,004 hectares or around 1,500 ha/year of land use has changed especially green area, see Table- 2^{5} . In addition the increasing of population will also induce the extraction of ground water that caused land subsidence. Based on Abidin et.all that studied relationship between urbanization in Jakarta with the land subsidence, they found that the range of land subsidence varies from location to location, based on the result of leveling surveys between 1982 and 1997,

eleven GPS surveys between 1997 and 2008, and InSAR technique between 2006 and 2007 showed that land subsidence in Jakarta had large spatial and temporal variations. Observed subsidence rates were generally ca. 1-15 cm/year but can up to 20-25 cm/year for certain location and/or time periods^{7,8)}. The causes of flood in Jakarta mainly by climate change that increase rainfall intensity and sea level rise and the impact of flood become worse because of urbanization that change the land use, induce land subsidence and insufficient of infrastructure .

3. Flood Inundation

Flood event in 2002 and 2007 have inundated large part of Jakarta with the range of inundation depth from 11 cm to 250 cm. Figure-1 shown the inundation depth, land subsidence point and main river in Jakarta. Most of inundated areas located at northern part and along the river side. The effect of land subsidence to inundation depth would be depending on the topography of location. The lower area will have severely effect

able-2 Land	Use Change	1989	to 2001

Land Use 1989	Land Use 2001	Change
Water Body	Green Area	46.37
Water Body	Moderately Build-up Area	220.78
Water Body	Green Area	652.65
Water Body	Moderately Build-up Area	1,626.67
Water Body	Moderately Build-up Area	588.27
Moderately Build-up Area	Crowded Build-up Area	2,473.04
Green Area	Water Body	114.27
Green Area	Moderately Build-up Area	5,908.94
Green Area	Crowded Build-up Area	1,377.80
Moderately Build-up Area	Crowded Build-up Area	4,995.44
TC	TAL	18,004.23



Figure-1 Flood Depth and Land Subsidence

Table-3 Inundation Area by 2002 and 2007 flood Event

N.,	ا معط المم	Total Area	Inundatiion area (hectares) by inundated depth				Total Inundation	% of Total	
NO	Lang Use	(hectare)	176 - 250 cm	106 -175 cm	76-105 cm	41-75 cm	0-40 cm	(hectare)	Area
1	Sea water	7			6	0	0	7	0.01
2	Fresh water body	925	23	265	224	220	53	785	1.14
3	Shrub	319	6	57	110	41	21	235	0.34
4	Pond	830		435	190	0	2	628	0.92
5	Building	1,118	14	216	263	283	106	882	1.29
6	Forest	55		55				55	0.08
7	Garden	1,818	37	125	816	176	40	1,193	1.74
8	Sand	1,897		36	2	33	7	79	0.11
9	Sand beach	37		0	37			37	0.05
10	Settlement	41,555	1,230	4,554	12,120	6,856	3,215	27,975	40.79
11	Swamp	134		11	61	56		128	0.19
12	Grass	12,318	190	2,576	3,341	1,914	839	8,860	12.92
13	Rice field	4,816	37	549	1,654	715	107	3,062	4.46
14	Rocky soil	459		148	28	61	158	395	0.58
15	Field	2,291	30	101	852	239	57	1,278	1.86



Figure-2 Land Use Inundation Map

because land subsidence will decrease the elevation and will increase the inundation depth at that area.

Figure-2 shown land use allocation and inundation depth. Among 15 land use allocations in Jakarta as shown in Table-3, settlement

was the most severely inundated land use, around 27,863 hectares or around 41 % of total Jakarta area. This figure showed that settlement is the most vulnerable land use to flood disaster. The highest inundation depth located in the area where the land use allocation dominated by settlement and also being flow through by the main river.

4. Flood Vulnerability Map

Inundation depth; land use allocation; population density; land subsidence rate; flood event; distance to the river and

distance to the sea were used in generating flood vulnerability map. GIS application was used to generate this map. Among 261 villages in Jakarta, 44 villages are categorized as very vulnerable area as shown in Figure-3, 126 villages are categorized as moderately vulnerable area and 13 villages are categorized as vulnerable area.

5. Conclusion

This study evaluated the inundated land use by flood event in Jakarta. Jakarta is vulnerable to flood disaster either caused by rainfall or tidal activities. The vulnerability becomes higher as the impact of land subsidence and land use change especially for settlement. Most of the inundation areas are settlement that located near to the river and along coastal area. To reduce the impact of flood risk this study proposed the vulnerability map. It can be conclude that the most vulnerable land use to flood disaster in Jakarta is Settlement. The vulnerability map hopefully could be used as the basis in allocating suitable land use to reduce the impact and improvement infrastructure for protecting Jakarta from flood.



Figure-3 Vulnerability Map

Reference

- 1. Jakarta Regional Government (Pemda DKI Jakarta), Mengapa Jakarta Banjir, 2010
- 2. Brinkman, JanJaap, Hartmant and Marco; Jakarta Flood Hazard Mapping Framework, 2007
- 3. UNDP-Indonesia, Sisi Lain Perubahan Iklim, Mengapa Indonesia Harus Beradaptasi untuk Melindungi Rakyat Miskinnya (2007)
- 4. Jakarta Province's Public Work Departmen (2008), Flood Mitigation Handbook.
- 5. Regional Development Board DKI Jakarta (Bappeda DKI Jakarta)
- 6. Titus, James, Vijay K. Narayanan, 1995. The Probability of Sea Level Rise.
- 7. Hanuddin, Z. ABIDIN, DJAJA R, ANDREAS H, Dharmawan D, GAMAL M; land Subsidence Characteristic of Jakarta between 1997 and 2005, as estimated using GPS survey, GPS Solution 12. 23-32
- Hasanuddin Z. ABIDIN, Hadi S, Akbar A, Rajiwiryono H, Sudibyo Y, Meilano I, Kusuma MA, Kahar J Subarya, DREAS, Irwan GUMILAR, Mohammad Gamal, Yoici FUKUDA, and T. DEGUCI, Land Subsidence and Urban Development In Jakarta (Indonesia), 7th Regional Conference, Spatial Data Serving People; land Governance and the Environment 19 22 October 2009