Estimation of 2013 Jakarta Flood Damage Costs

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1. INTRODUCTION

Flood is one of natural disaster that cause many damage for human. There are two kind of damage i.e., tangible damage and intangible damage. Tangible damage is every damage that can be calculate e.g. house damage, income damage, etc. and intangible damage is every damage that cannot be calculated e.g. human life, comfort felling etc. In January 2013, flood occurred in the capital of Indonesia, Jakarta. It caused some damages both of tangible or intangible damage. The main objective of this paper is to estimate the tangible damage of 2013 Jakarta flood.

2. STUDY AREA

Jakarta is the capital of Indonesia which has total area is 662.33 km^2. It also has high population density with total of population in 2014 is approximately 10 million people. Economically, Jakarta has major role in Indonesia economic growth, it has gross domestic production (GDP) is approximately 130,344.12 (Million US Dollar) or means 16.45% of GDP of Indonesia. Jakarta is located in Java Island as show in **Fig.1**.

Fig.1 Map of study area

3. METHODOLOGY

Estimation of flood damage costs consist of modelling flood inundation and calculating damage costs. Moe. et.al (2015) already developed 2013 Jakarta flood inundation model. For calculating damage costs, we use the calculating damage costs procedure that contained in the flood control economy investigation manual published by the MLIT (2005).

Paddy field damage was calculated using the following formula:

Damage (Rp) = 564 (ton/km^2) x 4288.29x10^3 (Rp/ton) x inundated area (km^2) x damage rate by inundation depth (1)

Where 564 (ton/km^2) is average paddy field productivity and 4288.29x10^3 (Rp/ton) is the average rice price at farmer level in west java (nearest province to Jakarta).

The other agriculture land damage was determined using the following formula:

Damage (Rp) = 2088 (ton/km^2) x 2800x10^3 (Rp/ton) x inundated area (km^2) x damage rate by inundation depth (2)

Where 2088 (ton/km^2) is Indonesia average cabbage productivity (PUSDATIN, 2013) and 2800x10^3 (Rp/ton) is the average cabbage price at market.

Cabbage was chosen as crop for damage costs estimation, because it is the most crop that produced in Jakarta. And we only choose one kind of crop, because if the market demand change from one kind crop to another crop, automatically farmer will change their product.

Damage cost for residential building consist of house damage and household furniture damage as the following formula:

House damage (Rp) = 720,000.00/m^2 x inundated floor area x flood damage rate (3)

Where 720,000.00/m^2 is house price per area in Jakarta. It is obtained by assuming total area per minimalist type house is 36 m^3 and the price of one minimalist house in 2012 is 259,000,000.00 rupiah (BPS website).

For household furniture damage, we cannot get data the household furniture value per house in Jakarta. So, we approach with rational method. By assuming the household furniture value ratio proportional to the wage of employee ratio as the following equation:

$$HF_x = \left(\frac{1}{n}.\sum_{i=1}^{n}\frac{W_x}{W_i}xHF_i\right) \quad (4)$$

Where HF is household furniture value, W is wage of employee and n is number of data.

By using (4) and Japan data (Kazama et.al 2009) we obtained damage costs equation for household furniture as following:

Household damage (Rp) = Number of inundated house x 245,589,338.16 Rp/house x Flood damage rate (5)

Where 245,589,338.16 Rp/house is furniture value per household.

Similar case with household furniture damage, for obtaining office asset value. By assuming, asset value/person are equivalent to the ratio of GDP and employee number as following equation:

$$AV_x = \left(\frac{1}{n}.\sum_{i=1}^{n}\frac{\left(\frac{GDP_x}{EN_x}\right)}{\left(\frac{GDP_i}{EN_i}\right)}xAV_i\right) \quad (6)$$

Where AV is asset value, GDP is gross domestic product, EN is number of employee and n is number of data.

By using (6), we obtained the damage costs equation both production office and service office as following:

Production damage = Employees number x (289,453,803.10 Rp/Employee x amortized asset damage rate + 253,098,281.85 Rp/Employee x stock asset damage rate) (7)

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Where 289,453,803.10 Rp/Employee is amortized asset value per employee and 253,098,281.85 Rp/Employee is stock asset value per employee.

Service damage = Employees number x (218,133,127.55 Rp/Employee x amortized asset damage rate + 16,478,423.23 Rp/Employee x stock asset damage rate) (8)

Where 218,133,127.55 Rp/Employee is amortized asset value per employee and 16,478,423.23Rp/Employee is stock asset value per employee.

Traffic zone damage was calculated from the relationship to general asset damage because it is too difficult to estimate traffic damage directly from traffic assets:

Traffic zone damage = general asset damage x 1.694 (9)

Where ‘‘general asset damage = house damage + household furniture damage + office amortized assets and stock asset damage,’’ and 1.694 is the ratio of the cost of damage to public facilities to the cost of damage to general assets (MLIT 2005).

The damage rate was obtained from the flood control economy investigation manual (MLIT 2005). **Fig 2** shows the continuous relationship between the damage rate and inundation depth in the case of 1–2 days of inundation.

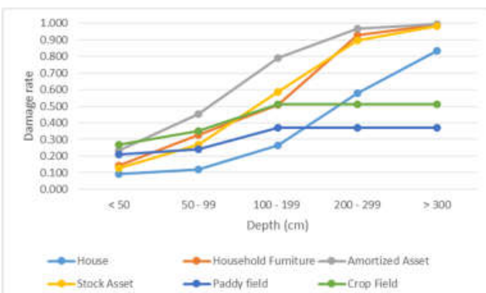

Fig.2 Flood damage rate based on inundation depth

4. RESULT AND DISCUSSION

2013 flood inundation model was classified based on inundation depth in **Fig.2**. We also apply damage costs equation to the Jakarta land use map (Bappeda 2009). **Fig.3** and **Fig.4** are the result of 2013 Jakarta flood damage costs analysis.

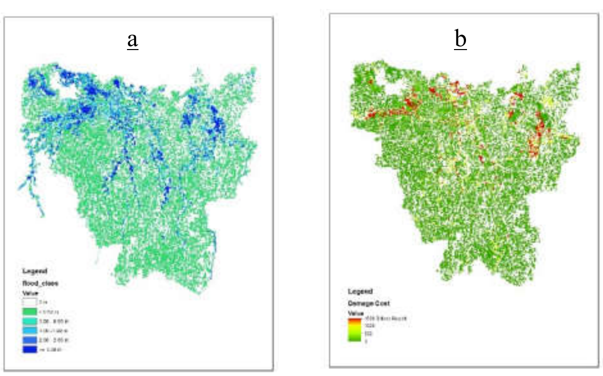

Fig.3 a) Spatial map of 2013 Jakarta Flood inundation and b) Spatial map of 2013 Jakarta flood damage costs

Fig.4 shows that the most contribution of 2013 Jakarta damage costs is business sector both of production office and services office. And lowest damage cost is agriculture sector both of paddy field and crop field. **Fig.3** shows the distribution of damage costs, this result will help to decide the priority area where will be protected from flood.

Fig.3 2013 Jakarta flood damage costs distribution

5. CONCLUSIONS

Based on the above explanations, we obtain the following conclusions:

1. The highest impact of 2013 Jakarta flood is to business sector, and the lowest impact is agriculture sector. It means Jakarta as urban area.
2. Damage costs depend on both of depth of inundation and economic value of land use.
3. From this result, we can decide the most vulnerable area. Therefore, we make priority flood protection action.

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REFERENCES

Kazama S., Sato M., and Kawagoe S (2009) Evaluating the cost of flood damage based on changes in extreme rainfall in Japan. Sustain Science 4:61–69

Ministry of Land, Infrastructure, Transport and Tourism (MLIT) (2005) The flood control economy investigation manual (draft), River Bureau (in Japanese)

Moe I R., Kure S., Farid M, Udo K., Kazama S., and Koshimura S (2015) Numerical simulation of flooding in Jakarta and evaluation of a counter measure to mitigate flood damage, Journal of Japan Society of Civil Engineers,Ser.G (Environmental Research), 71(5),pp.I_29-I_36.