Infiltration Wells for Reducing Flood Inundation in Jakarta

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1. INTRODUCTION

Jakarta is the capital city of Indonesia that has population more than 10 million people with the annual population growth rate in 2010 until 2014 is 1,11 %. The high population can produce some problems, one of them is uncontrolled groundwater extraction. Abidin et al (2011), they found that the increasing of groundwater extraction made the higher of land subsidence. And also land subsidence contributed for the flooding in Jakarta (Abidin et al, 2015 and Moe et al 2016). In this study, we asses a countermeasure for reducing flood damage and land subsidence in Jakarta. We evaluate it by installing of infiltration well in inundated area to know how many percent of inundation area can be reduce and how much water can infiltrate into groundwater.

2. STUDY AREA

Study area of this study is Jakarta city that is one of area in Indonesia that has high flood occurrences. From 2005, BNPD (Indonesia rescue body) recorded that more 20 occurrences of flood with different magnitude. There are thirteen rivers flowing into Jakarta with the main river is Ciliwung river. **Fig 1** shows the watershed of rivers in Jakarta.

Fig.1. Watershed of rivers in Jakarta

3. METHODOLOGY

2.1. Flood Inundation Model

Moe et al (2015 & 2016) have developed flood inundation model for Jakarta city, they have succeeded to calibrate the flood inundation model with 2013 Jakarta flood event. The model consists of rainfall-runoff model at each Subbasin, flow in river and flood inundation simulation on the land.

For rainfall runoff, we used rainfall runoff model that was proposed by Kure et al (2008 & 2013). The model simulates rainfall runoff process based on the geology and hydrology condition for each subbasin. For urban areas, it simulates as the Hortonian overland flow and for mountainous areas, simulating as sub surface and saturation overland flow.

For flow in the river, one-dimensional of continuity and momentum equation (Saint-Venant equation) were used for flow in the river. The Saint-Venant equations are written as follows:

$$\frac{\partial A}{\partial t} + \frac{\partial Q}{\partial x} = q_l \qquad 1)$$

$$\frac{\partial Q}{\partial t} + \frac{\partial \left(\alpha \frac{Q^2}{A}\right)}{\partial x} + gA\frac{\partial h}{\partial x} + \frac{gn^2|Q|Q}{R^{4/3}A} = 0 \qquad 2)$$

where, Q is the discharge (m^3/s), A is the flow area (m^2), q_l is the lateral inflow (m^3/s), n is the manning resistance coefficient, α is the momentum distribution coefficient, g is the gravity acceleration (m/s^2), h is the water level (m), and R is the hydraulic or resistance radius (m).

For overland flow, the two-dimensional of the continuity and momentum equation were solved numerically for overland flow. The lateral link was used for coupling flow in the river and overland to represent spilling from the river to the flood plain and drainage back into the river.

2.2. Infiltration wells

There are some rules for installing, one of them is the spacing of infiltration wells. Massmann (2004), the recommended spacing for shallow water table is approximately 25 m. Infiltration wells spaced more closely than these recommended rates may still be effective, but some reduction in infiltration rates could be caused by overlapping mounds.

For this study, we installed infiltration well in two domain area with spacing of infiltration wells is 60 m (see **fig.2**). And with assumption, the saturated hydraulic conductivity is 91 mm/hour (sandy loam soil), we can the steady infiltration rate for double barrel infiltration well is 0.0003 m^3/s (13 mm/hour per one cell grid). With total of number infiltration wells are 30375 wells.

4. RESULTS AND DISCUSSION

In this study, we apply rainfall 2 and 50 years return period into the model. We found that after 43 hours the simulation, the inundation area of flood for two rainfall scenarios is decreasing 4.4 % and 3.9 % respectively. And also we found that the difference volume of water before and after installing infiltration wells are 517076 m^3 and 692018 m^3. For the detail, we can see **Fig.2.**

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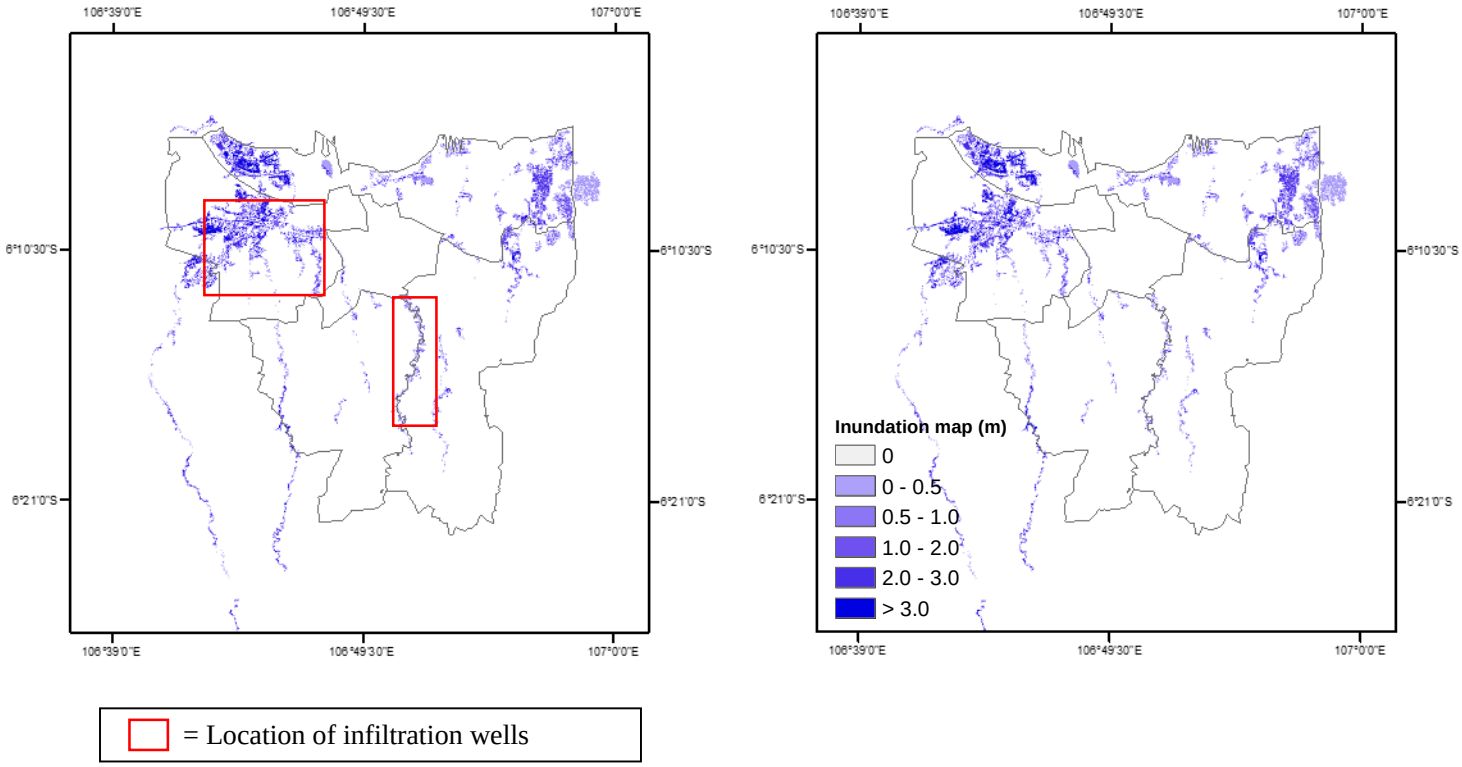

Fig.2. Flood inundation map before (left) and after (right) installing infiltration wells for 50 years return period

Abidin et al (2011) found that there is relationship between the volume of groundwater extraction and land subsidence rate. If we can use water of flood for recharging groundwater, so that we can reduce the rate of land subsidence in Jakarta. However, we do not know the real volume of groundwater extraction, because there are many illegal wells in Jakarta.

5. CONCLUSIONS

From the above explanation, we can conclude as follows:

1. The inundation area of flood for rainfall 2 and 50 years returns period are decreasing 4.4 % and 3.9 % respectively. And also we found that the difference volume of water before and after installing infiltration wells are 517076 m^3 and 692018 m^3.
2. The infiltration wells slight effective for reducing flood inundation and recharging groundwater, however we should combine with another countermeasure so that we can decrease the number of infiltration wells.

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