Residential Area Contribution To Reducing Flood Rate From Climate and Landscape Change

1Kusumastuti and 2Kuntjoro

1Institut Teknologi Sepuluh Nopember Surabaya (ITS), Civil Engineering Department, Civil Engineering and Planning Department, Surabaya 60111, Indonesia. 2Institut Teknologi Sepuluh Nopember Surabaya (ITS), Civil Engineering Department, Civil Engineering and Planning Department, Surabaya 60111, Indonesia (corresponding author).

ABSTRACT

Background: Climate and landscape change tends to increases run off. This research intended to capitalize potential residential as contributor flood control. Method: The Horton formulation used with inputs variable climate pattern change and the rainfall pattern change, by the residential land infiltration capacity condition. Results: Rainfall pattern such as Figure 5 and its duration is 81 minutes, height of rainfall is 95.67 mm. Land infiltration capacity is analyzed from the Figure 6 will be able to control flood as high as 38.91 mm. its mean that 38.91 liters on one m² of land. Conclusion: Flood rate from run off caused by climate and landscape change is 0.05676 metres its mean that 56.76 liters on one m² of land.

INTRODUCTION

Considering landscape change tend to increases run off, it was needs a flood control method, simple and easily be implemented by land users. Systematically this method invented would be reduce drainage facilities load as well as land and groundwater conservation. So that residential be a contributor flood control.

Land users as run-off producer has two positive potentials that are as control his own run-off and as the recharge area for soil water filling to the acreage that allows infiltration. Two potential above will be developed in this research. By using this residential potential, it will reduce the facilities and pre facilities drainage load. This is flood control in the utmost degree upstream imposed in users land and was a cheap flood preventive.

Flood vulnerability an area of flood depends many factors, among other forms of topography, covers land and the rainfall pattern (Kuntjoro, M. Bisri, et al, 2015). Factors that provisions then were particularly will be consideration in this research, because in research or design for residential and other infrastructures and related to hydrological incident, this factor almost always used extreme condition (Kuntjoro, et al, 2013), (Kuntjoro, et al, 2015).

Each region have different character pattern of the season or climate (Robert Henson, 2011). Climate change as the rainfall intensity, silt of pattern of the rainy season and dry season also increased complexity the flood problem for the last decade (Kuntjoro, 1997), (Kuntjoro, 2006), (Kuntjoro, 2011). Depart from character the form of topography, land covering (land used) and the rainfall pattern, so planning and / or empowerment residential in flood control contribution cannot be done based on extreme condition as that had been undertaken.

MATERIALS AND METHODS

The research is done in Surabaya, in the “Pondok Maritim” residential with residential area 38.9 ha and The existence of research locations nearby Wiyung lake as shown in Figure 1.
Local Rain Fall Intensity:

Height rainfall of the daily recorded with manual rainfall recorder at the station closest to research locations. Recording been twenty five years, from 1989 up to 2013. Height of maximum daily rainfall for that range time is 196 mm.

Distribution of height daily rainfall in a year is reflection of pattern local season. From the pattern recorded 1989 - 2013 can be included shifting patterns of the season (climate) (Rupp Andre, A., et al., 2010), in terms of the peak of the dry season that is in September, in observation data pattern the seen from 1989 - 2013 the peak of the dry season still around September, not found shift of the season (climate) significant.

From the span of 1989 - 2013 exemplified pattern the season of the year 1989 in Figure 2. and the pattern the season of the year 2013 shown in Figure 3.
Distribution of rainfall in one day expressed in a pattern rain, it is obtainable from the measurement of the precipitation with an Automatic Rain Fall Recorder (ARFR) as seen in Figure 4. Discretion of precipitation data automatic and by following this rainy pattern on maximum rainfall been twenty five years is 196 mm and expressed in Table 1, and the pattern as Figure 5.

**Fig. 4: Rainfall pattern from ARFR**

**Table 1: The rainfall distribution**

<table>
<thead>
<tr>
<th>Rainfall R (mm)</th>
<th>36.11</th>
<th>41.26</th>
<th>77.37</th>
<th>25.79</th>
<th>15.47</th>
</tr>
</thead>
<tbody>
<tr>
<td>Duration (minutes)</td>
<td>5</td>
<td>5</td>
<td>10</td>
<td>38</td>
<td>24</td>
</tr>
</tbody>
</table>

**Fig. 5: The rainfall pattern**

*The land infiltration capacity:* Land infiltration capacity measured by ring infiltrometer for soil sample from research locations, the results be expressed as Table 2 and Figure 6.

**Table 2: The land infiltration capacity**

<table>
<thead>
<tr>
<th>Duration (minutes)</th>
<th>Draw Down (cm)</th>
<th>Duration (hours)</th>
<th>$f$ (cm/hours)</th>
<th>Land Infiltration Capacity $f$ (mm/minutes)</th>
</tr>
</thead>
<tbody>
<tr>
<td>7.57</td>
<td>0.30</td>
<td>0.13</td>
<td>2.38</td>
<td>0.40</td>
</tr>
<tr>
<td>7.82</td>
<td>0.30</td>
<td>0.13</td>
<td>2.30</td>
<td>0.38</td>
</tr>
<tr>
<td>20.00</td>
<td>0.25</td>
<td>0.33</td>
<td>0.75</td>
<td>0.13</td>
</tr>
<tr>
<td>50.00</td>
<td>0.25</td>
<td>0.83</td>
<td>0.30</td>
<td>0.05</td>
</tr>
<tr>
<td>75.00</td>
<td>0.25</td>
<td>1.25</td>
<td>0.20</td>
<td>0.03</td>
</tr>
<tr>
<td>100.00</td>
<td>0.10</td>
<td>1.67</td>
<td>0.06</td>
<td>0.01</td>
</tr>
<tr>
<td>120.00</td>
<td>0.10</td>
<td>2.00</td>
<td>0.05</td>
<td>0.01</td>
</tr>
</tbody>
</table>
Table 1: Flood control calculation

<table>
<thead>
<tr>
<th>I</th>
<th>f</th>
<th>ΔI</th>
<th>Δf</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.10</td>
<td>2.00</td>
<td>0.05</td>
<td>0.01</td>
</tr>
</tbody>
</table>

Fig. 6: The Land infiltration capacity graph

Method:

The equations and procedure analysis guidance:

Formula Horton (Todd D K, 1980) used to calculate the amount of rain water that will be run-off, expressed in the equation of follows:

\[ f = f_c + (f_0 - f_c)e^{-kt} \]  \hspace{1cm} (1)

where:

- \( f \) : The capacity of infiltration at the time of \( t \) (mm/hours)
- \( f_c \) : The capacity of infiltration in large \( t \) (mm/hours)
- \( f_0 \) : The capacity of infiltration at \( t = 0 \) (mm/hours)
- \( t \) : The duration of rain (minutes)
- \( k \) : The constant for a type of soil and its surface (minute\(^{-1}\))

Horton equation is only valid for \( I > f \), where \( I \) is rainfall intensity and \( f \) is infiltration capacity.

For the condition \( I < f \) apply the equation:

\[ f_2 = f_1 - k(I - f_1)\Delta t \]  \hspace{1cm} (2)

where:

- \( f_1 \) : Infiltration capacity at the beginning of time \( t \) (mm/hours)
- \( f_2 \) : Infiltration capacity at the end of time \( t \) (mm/hours)

Analysis Procedures Residential Empowerment As Flood Control Contributor:

1. Discretize rainfall data ARFR be variable discrete, be rainfall intensity \( I \) (mm/minutes)

2. Land infiltration capacity \( f \) (mm/minutes) considering with the landscape change and topography.

3. Plot the rain intensity graph with the land infiltration capacity graph

4. Analysis the difference between the rain fall intensity with land infiltration capacity.

5. The positive value in the difference was the height of water should been distributed to residential areas

6. The negative value at the difference meant that residential contribute directly in flood control.

7. The residential contribution as the flood control is the value of the difference positive times the residential areas.

RESULTS AND DISCUSSION

Rainfall pattern such as Figure 5 and its duration is 81 minutes, height of rainfall is 95.67 mm = 0.09567 m, its mean that 95.67 liters on one m\(^2\) of land.

Land infiltration capacity is analyzed from the Figure 6 will be able to control flood as high as 38.91 mm = 0.03891 m, its mean that 38.91 liters on one m\(^2\) of land.

Flood should be controlled by residential for rainfall intensity in one year return period (\( R_1 \)) is the difference between the rainfall intensity with infiltration capacity, expressed in Figure 7.

Run off caused flooding from climate and landscape change is 0.09567 m – 0.03891 m = 0.05676 m its mean that 56.76 liters on one m\(^2\) of land.
Fig. 7: Residential flood control contribution

**Conclusion:**

- Climate and landscape change had been cause additional run off 0.09567 m
- Each owner land should be responsible for their own run-off 56.76 liters per square meters

**Recommendation For Future Work:**

- Conservation water in residential areas could be done by separate retardation.
- Need more research on separate retardation model

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**REFERENCES**


Kuntjoro, 2006. Waktu Yang Diijinkan Untuk Menggenang Pada Suatu Lahan (Permitable Retarding Duration Of Land PRD), LPPM ITS


Kuntjoro, M Bisri, S Agus, M Aniek, (2013), River Bed Erosion and Sedimentation Behavior in Discharge Fluctuation Condition, Middle East Journal of Scientific Research 18, 1851-1858


Linsly, 1996. Hidrologi Untuk Insinyur, Penerbit Erlangga