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Analysis of Infiltration and Runoff Using KINEROS Model in Kali Genteng Sub-catchment, Malang

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***Abstract*—** *The Kali Genteng sub-catchment is located at the upstream of the Lesti Watershed in Malang Regency. It is one of the important sub-catchment, mainly for being source of inflow for the Sengguruh Dam, on the other hand, it also become the source of loads of sediment into the Sengguruh Reservoir. Land use changes within the sub-catchment by clearing land for expansion of residential areas as well as for the addition of agricultural land causes a rapid reduction of forest areas which are able to absorb water (pervious) into impervious watershed areas.*

Runoff measurements in a sub-catchment or watershed directly in the field is still rarely found because the cost are realistically large and require considerable amount of time. For research and reference of runoff data there has to be an appropriate model approach and in accordance with the conditions of an area.

This study is expected to be able to illustrate the level of surface runoff in the Kali Genteng sub-catchment using the KINEROS model based on land use changes in 2012 and 2017 as well as with a 2-year and 5-year recurrent rain simulation. The results of the expenses analysis show that land use changes affect the infiltration and surface runoff and there is a relationship between land use and runoff. Maximum surface runoff occurs in 2017 which is 15,478 mm / minute.

***Keywords*—** *Runoff, KINEROS Model.*

I. INTRODUCTION

Water is an essential requirement for all human activities such as for drinking, agriculture, and power generation. Indonesia country has the world's fourth largest population (207.6 million according to the 2000 census) with over 92% being Muslim after China, India, and the United States. The population is comprised of nearly 300 ethnic groups that speak about 538 different languages and dialects. Indonesia has two seasons of climate, rain season and dry season. This condition, the government must be giving more attention for difference situation.

In present decade, development all sector more intensive to increase of economic target. Development can increase not only capital income of people but also human health. In the another aspect, the development need more land to built infrastructure like road, building, market area, residential, industries estate, etc. It was effect to changes of land use/land cover in many place. The land use changes from pervious layer to impervious layer in catchment area can change the hydrological system. It was influence of runoff in downstream area. The increasing of runoff in high land can indirect flooding disaster in low land. Therefore, it needed to development a model that can be use to predict of runoff as basin scale.

II. OBJECTIVES

The study was carried out with the following objectives:

1. To determine the runoff in Kali Genteng sub-catchment area.
2. To look for the impact of land use change on runoff in Kali Genteng sub-catchment area

III. THEORIES

The precipitation file created for the watershed can be account for variations in precipitation levels as on transgresses the watershed by placement of rain gauge within specific element or cell of the simulated. By weighting this rain gauge differently, different rainfall amount can be simulated over the watershed.

Rainfall excess, which leads to runoff, is defined as the difference between precipitation amount and interception and infiltration depth. The rate at which infiltration occurs is note constant, but depends on the rainfall rate and accumulated infiltration amount, or the antecedent moisture condition of soil. One of the benefits of vegetation is that the soil water content is reduced by evapotranspiration. The depression in soil water content increases the amount of precipitation that can infiltrate into the root zone of the soil matrix. If the rate of rainfall is the limiting factor, then infiltration rate equals precipitation rate and no ponding will occur.

A. Hydrology Analysis

The result of hydrological analysis is rainfall intensity in several periode as input data for model development.

B. KINEROS

The kinematic runoff and erosion model KINEROS is an event oriented, physically based model describing the processes of interception, infiltration, surface runoff and erosion from small agricultural and urban watersheds. The watershed is represented by a cascade of planes and channels; the partial differential equations describing overland flow, channel flow, erosion and sediment transport are solved by finite difference techniques. The spatial variation of rainfall, infiltration, runoff, and erosion parameters can be accomodated. KINEROS may be used to determine the effects of various artificial features such as urban developments, small detention reservoirs, or lined channels on flood hydrographs and sediment yield.

KINEROS is a distributed model.Multi-gage rainfall input is distributed by assigning rain gages to overland flow planes.

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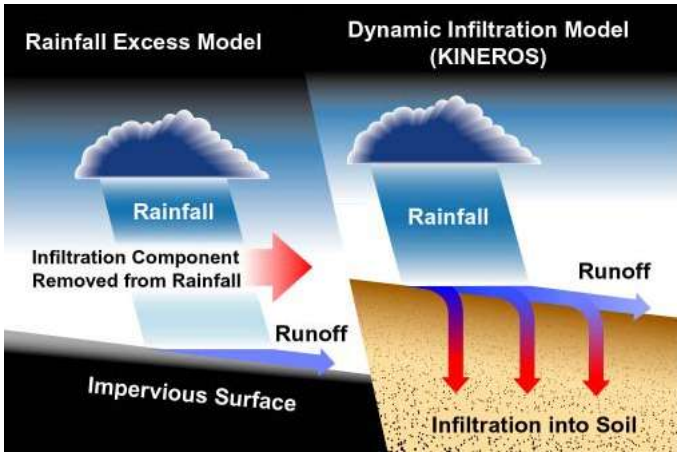
The infiltration algorithm is dynamic, interacting with both rainfall and surface water in transit:



C. *Analysis of Soil*

Analysis of soil texture and soil properties have been done in laboratory. The rerults of soil analyisis as input data for KINEROS model.

IV. METHODOLOGY

A. *Study Area*

Kali Genteng sub-catchment area is located in Malang Regency, East Java. Geographically, it is situated between 7°47'12,41" – 7°54'50,04" LS and 112°34'53,96" – 112°39'23,74" BT. The Area of Kali Genteng sub-catchment is 103,604 Km^2.

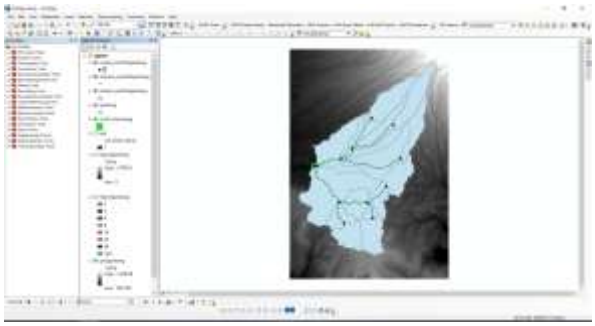
B. *Procedure of the study*

1. Collect the existing data.
2. Analyse the hydrological aspects
3. Digitize the map
4. Analyse the land use
5. Running and analyse KINEROS model
6. Calibration and validation of the chosen model
7. Mapping the runoff of Kali Genteng sub-catchment using the calibrated model

V. RESULT AND DISCUSSION

A. *Digitalize the Sub-catchment Area*

The result of this analysis are boundary of sub-catchment area and river network within the sub-catchment.



B. *Hydrology Analysis*

1. Analysis of Homogenous Rainfall

Based on the analysis with Q/√n calculation < Q/√n table dan R/√n calculation < R/√n table, so the rainfall data from Dampit station is consistent.

2. Analysis of Inlier-Outlier

Based on the analysis of *Inlier-Outlier* all rainfall data from Dampit Station is within range from Xh to XL.

3. Analysis of rainfall probability

This analysis using Log Pearson Type III methode. From the calculation can be seen below.

Table 1. Curah Hujan Rancangan

No	**Tr**	**CH Rancangan**
	(tahun)	(mm)
[1]	**[2]**	**[3]**
1	1,01	88,59
2	2	141,91
3	5	178,45
4	10	203,88
5	25	237,52
6	50	263,70
7	100	290,88
8	1000	390,98

4. Analysis of Probability Distribution

a) Smirnov-Kolmogorov Tes

Based on calculation Δ_{max} = 0,112, Δcritis for *Smirnov Kolmogorof* Test (n = 10) α=5%, $\Delta_{kritis} > \Delta_{max}$ so the distribution is acceptable.

b) Chi Square Test

X^2 calculation = 0,4, X^2 critis for α (derajat kepercayaan) 1% = 6,635 snd 5% = 3,841, so *Chi-Square* Test is also acceptable too.

5. Rainfall Intensity

The result of hydrological analysis is rainfall intensity in 2 and 5 return periode. Based on the calculation, it can be summarized 35,271 mm/hour for 5 year, and 28,049 mm/hour for 2 year.

C. *Analysis of Land Use Map*

Distribution of land use in the sub-catchment area presented in table below.

Distribution of land use in 2017

No	Penggunaan Lahan	Luas	Prosentase
		(Ha)	(%)
1	Belukar	218,628	2,11
2	Hutan Lahan Kering Sekunder	498,240	4,81
3	Hutan Tanaman	73,170	0,71
4	Perkebunan	1002,096	9,67
5	Permukiman	2604,999	25,14
6	Pertanian Lahan Kering	0,063	0,00
7	Pertanian Lahan Kering Campur	5963,163	57,56
Jumlah		10360,360	100,00

Distribution of land use in 2017

No	Penggunaan Lahan	Luas	Prosentase
		(Ha)	(%)
1	Belukar	284,048	2,74
2	Hutan Lahan Kering Sekunder	542,087	5,23
3	Hutan Tanaman	86,495	0,83
4	Perkebunan	1062,028	10,25
5	Permukiman	1042,295	10,06
6	Pertanian Lahan Kering	0,450	0,00
7	Pertanian Lahan Kering Campur	7342,958	70,88
Jumlah		10360,360	100,00

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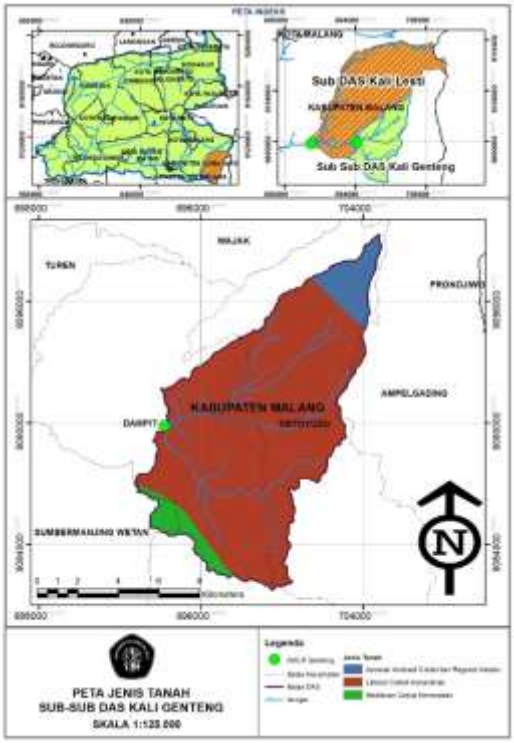


Map of Soil Texture in Sub-catchment Area

D. Runoff Modelling Using KINEROS

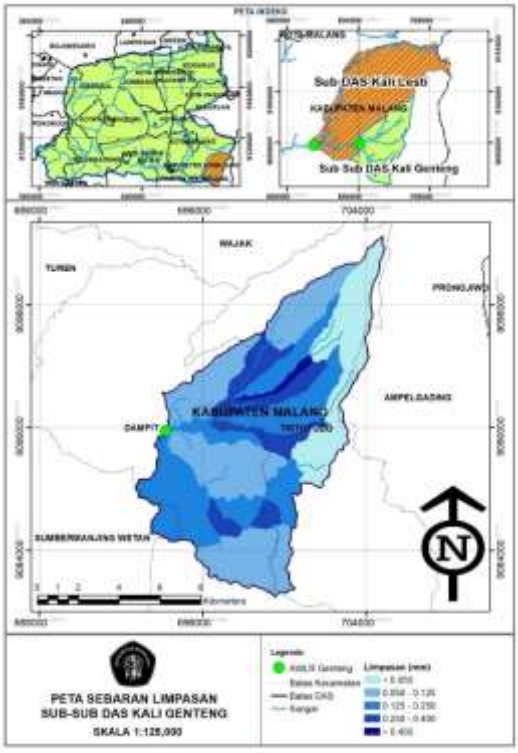
The parameterization of AGWA aims to find out basic parameters such as soil hydrology type, manning roughness coefficient, hydraulic conductivity effective saturated area (Ks), capillary drive (G), Porosity (θ). In the Kineros model a parameter properties table for land use and soil types has been provided, namely North American Landscape Characteristic (nalc_lut) and kin_lut. The percentage of land use and its coefficients.

Rainfall data included in write kineros precipitation is a ten-year average rainfall data for ten years in the form of a hyetograph. Hyetograph is a graphical representation of the distribution of rainfall intensity over time. Hourly rain data is arranged in the form of cumulative hourly rain. Then the available data will be running according to the stages of KINEROS.

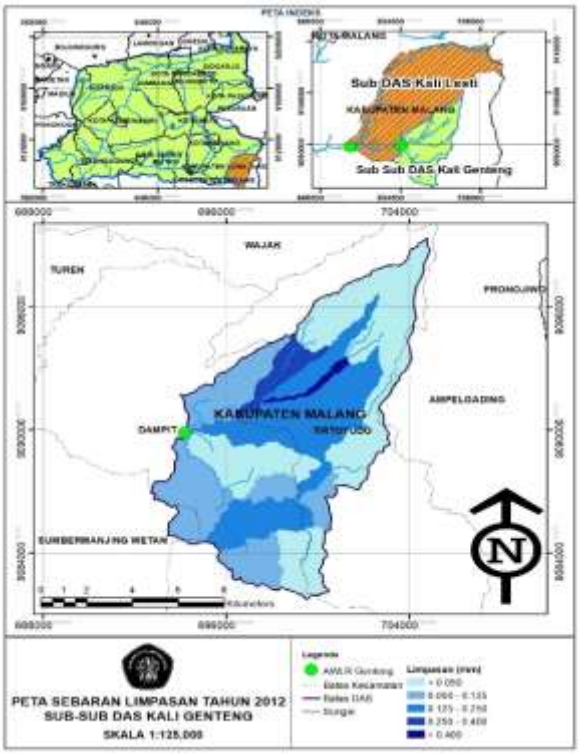
The results of the initial running of AGWA show the magnitude of infiltration in units of millimeters per hour, because the hourly rainfall data used. Therefore, to compare with the results of measurements in the field, the unit changes to millimeters per minute.

In addition to the calculation of infiltration with KINEROS, field measurements became an alternative as a comparison data from the results of the KINEROS model. Based on the results of running AGWA, calibration was carried out with the results of field measurements using the NSE statistical method.

Calibration of the chosen model was done in 3 scenarios, to look for the closest NSE to 1.



Map of runoff using KINEROS in 2017



Map of runoff using KINEROS in 2012

E. Comparison of Rain, Infiltration and Runoff

Based on the results of the runoff calculation, there has been an increase in runoff value from 2012 to 2017 which is 2,073 mm for minimum runoff in 2012 to 2,632 mm in 2017.

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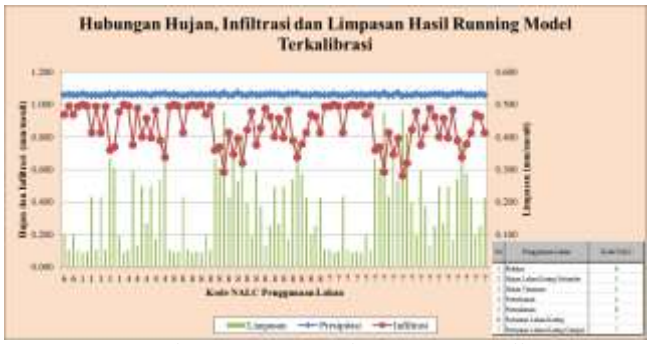
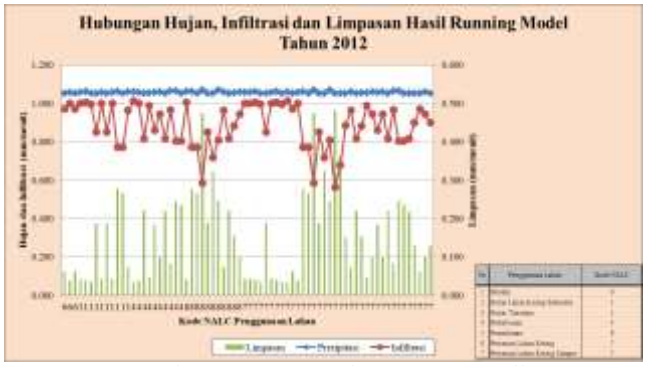
While the maximum runoff value for 2012 and 2017 is still 28,969 mm.



Graphic of Calibrated Rain, Infiltration and Runoff in 2017



Graphic of Calibrated Rain, Infiltration and Runoff in 2012

VI. CONCLUSION

The Kineros Model software used to carry out infiltrasion and runoff analysis in the Gentenf Sub Watershed run and be used after calibration adjustment on change 3 parameters in

The kineros software by adding a roughnes of 70%, Ks (*Soil Hydroulic conductivity*)and G(*Capillary drive)* each one 50%, the result NSE value og 0.682 was obtained, wich was included in the *Nash Suutcliffe Efficient* (NSE) range, namely 1.NSE.0, so that the kineros software hydrology model could be accepted. Based on the analysis, in 2012 for the minimum runoff value was 2,073 mm and in 2017 was 2,632 mm. the minimum runoff occurred on Plane 63. Runoff of Kali Genteng sub catchment area had increased from 2012 to 2017. The increase of the runoff happened because of land use change. Almost 1.562,705 Ha of land are changing into residential land.

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