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STUDY OF SURFACE RUNOFF BY USING GEOGRAPHIC INFORMATION SYSTEM

CASE STUDY: DAS (WATERSHEDS) POLEANG – RORAYA

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ABSTRACT

Hydrological analysis still a very dominant part of the analysis and require careful handling and calculation of top debit is a very important element in flood control. Rainfall, catchment area, as well as geographic information such as slope and land cover is a parameter for estimating debit by using rational method.

The purpose of this study is Estimating thedebit flow based on the rainfall data in the Poleang-RorayaRiver Region using open-source software-based Geographic Information System (GIS).

In this study calculated rainfall plans to return period of 2 years, 5 years, 10 years, and 25 years with the method of Log Pearson Type III distribution. By using the ArcGIS softwaredebit flow obtained was 377.05 m^3 / sec on a return period of 2 years; 448.17 m^3 / sec on a return period of 5 years; 482.00 m^3 / sec on a return period of 10 years; and 512.49 m^3 / sec on a return period of 25 years.

Keywords: Debit Flow, Rainfall, Rational Method, Geographic Information System, ArcGIS.

I. INTRODUCTION

Impact of land use change is the increased surface flow directly at the same time decreasing the water that seeped into the ground. The impact is more lame water distribution between rainy season and the dry season, drought and the threat of increased flooding increasingly rampant.

To overcome such problems required a planning water buildings or flood control. In the implementation of planning and designing buildings , water and flood control, analisishidrologi is still very dominant analysis section and requires careful handling

especially analysis determination of peak discharge. Geographic information systems (GIS) is sistem/toolfor creating maps digitally with requiring data attribute/description/tabular data from the map, so that from any petater can be a link to the data attribute. 30 data attributes can be created as needed, such as for example the vast acreage, land closure type, rainfall, and others. In this study a GIS system will be used to discharge mengestimasi flow.

II. RESEARCH OBJECTIVES

The purpose of this research was: analyzing and calculating discharge flow based ondata of rainfall in the region of the river Poleang-Roraya by using open-source software-based geographic information systems (GIS/GIS).

III. RESEARCH METHODOLOGY

an overview of the condition of the area of study in the administration of the river basin poleang-roraya in the province of south east sulawesi with number of watersheds (das) as much as 174 das. among the das that is part of the region of the river poleang-roraya one of the largest areas of her catch is das poleang. das poleang is the largest watershed in bombana district, southeast sulawesi, catchment area that is 1,090.33 km2. the length of the main rivers through the das poleang is 84 km.

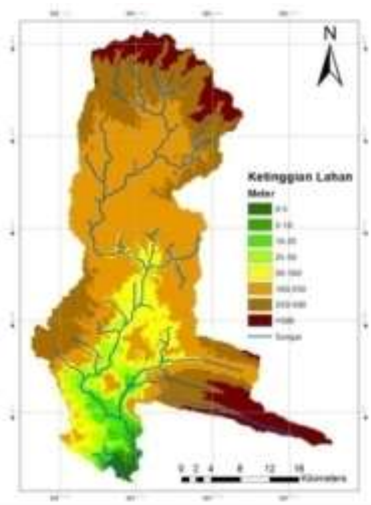

figure 1. poleang, bombana watershed, southeast sulawesi

Data Collection

the required data in this study are:
rainfall data obtained from rainfall stations around das poleang.
poleang watershed map
digital elevation model das poleang to determine slope slope/slope.
map of the area of land cover watershed poleang.

Implementation Of The Research

Analysis Of Rainfall Data
Determine the average rainfall with Thiessen method.

Determine the parameters of statistics based on the average rainfall.

Determine the right distribution pattern between Gumbel distribution, the distribution of the Log-Normal distribution, Log Pearson Type III distribution and Normal. The general formula is used: $X_T = X + K_T . S$

Do the testing distribution with Chi-Square test
Calculating Rainfall Intensity

Rainfall intensity analysis is done to get the intensity of the rainfall in the period

1 hour of maximum daily rainfall data. Determination of daily rainfall intensity in a particular birthday with Scorpion mononobe method:

$$I = \frac{R_{24}}{24}\left(\frac{24}{t}\right)^{2/3}$$

Where:
I = intensity of Rainfall (mm/h)
R_{24} = maximum rainfall in 1 day (mm)
t = duration of rainfall (hours)

Based on the above formula, then the IDF curves made (Intensity Duration Frequency) by varying the values of q. to determine the intensity of the rain, it should be calculated with the formula konsenterasi kiprich time as follows:

$$t_c = \frac{0{,}06628L^{0.77}}{S^{0{,}385}}$$

Where:
TC = Concentrate of time (hours)
L = length of the River (km)
S = the slope of the land between the elevation maximum and minimum

Calculate The Coefficient Of Runoff
The results of the classification of land cover and slope slope was changed to flow coefficient values using the Tabelnilai C average and calculated the value of c. C value Calculation based on the slope of the land and the closure of slopes can be seen in the following table.

Table 1. The value of C is based on the slope of the slopes

No.	Slope Class (%)	Value C
1	0 – 3	0.3
2	3 – 8	0.4
3	8 – 15	0.5
4	15 – 30	0.6
5	> 30	0.7

Table 2. The value of C based on land cover

No.	Land Cover	Value C
1	Primary Forest	0.01
2	Secondary Forest	0.05
3	Garden Mix	0.5
4	Moor Fields	0.5
5	Plantation	0.5
6	Scrub	0.3
7	Rice Fields	0.2
8	Asphalt Road	0.7
9	Open Land	0.95
10	The Seetlement	0.9

Calculate The Discharge Flow
The methods used to estimate discharge flow is the rational method. As for the rational method formula is as follows:

$$Q = 0{,}278.C.I.A$$

Where :
Q = Volumetric Flow (m^3/s)
C = Average runoff Coefficient (0-1)
I = Intensity off Rainfall (mm/h)
A = Area

IV. RESULTS AND DISCUSSION

Rainfall Data

Rainfall data used is the maximum daily rain shower data for the last 12 years beginning in 2003 until 2014. The following are the maximum daily rain shower in Bombana data at each station.

Table 3. Maximum daily rainfall Bombana Regency

No.	**Year**	**STA. Taubonto (mm)**	**STA. New Village (mm)**	**STA. Tampabulu (mm)**
1	2003	61	44	110
2	2004	95	61	126
3	2005	52	71	39
4	2006	53	67	40
5	2007	85	87	73
6	2008	80	90	82
7	2009	50	84	69
8	2010	74	70	120
9	2011	73	57	76
10	2012	92	70	80
11	2013	84	70	80
12	2014	80	76	91

Determine The Average Rainfall
Average rainfall with thiessen polygons.

Table 4. The average rainfall of thiessen method.

No.	**Year**	**Average Rainfall (mm)**
1	2003	75,109
2	2004	103,885
3	2005	48,282
4	2006	49,273
5	2007	81,541
6	2008	80,595
7	2009	55,542
8	2010	87,266
9	2011	73,838
10	2012	88,499
11	2013	82.465
12	2014	83,023

Determine The Type Of Frequency Distribution Of Rainfall

The terms select the type of distribution:

- When Cs = 0, the spatial used is the Normal spatial
- When Cs = 3Cv, spatial used is the spatial Log Normal
- When Cs = 1.4 danCk = 5.4, the spatial used is the spatial Gumbel
- If the third spatial above there is nothing to meet the then used spatial Log Pearson III

This type of distribution that is used in research is now a Log Pearson III
Calculation Method Of Logging Plans Rain Pearson III

Table 5. The Value Of The Distribution Log Pearson Type II

T	P(%)	Cs	G	Log X	X (mm)
2	50	-0.8575	0.1412	1.8833	76.4398
5	20	-0.8575	0.8548	1.9584	90.8613
10	10	-0.8575	1.1551	1.9900	97.7138
25	4	-0.8575	1.4244	2.0183	104.3003

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Test the fit by means of Chi-Square

Table 6. Calculation method of Chi-Squared

The value limits for each class			E_f	O_f	E_f-O_f	$\frac{(E_f-O_f)^2}{E_f}$
48.30	<Xi<	59.41	2.4	3	-0.6	0.15
59.41	<Xi<	70.51	2.4	0	2.4	2.4
70.51	<Xi<	81.62	2.4	4	-1.6	1.06
81.62	<Xi<	92.72	2.4	4	-1.6	1.06
92.72	<Xi<	103.8	2.4	1	1.4	0.81
Total			12	12		5.5

From the table the value of Chi-KuadratuntukDk = 2, using the significance of α = 0.05, obtained the price of the Chi-Kuadratkritis. From the above calculation results obtained, then it can be inferred that the distribution is qualified.

Analysis Of Rainfall Intensity

KurvaIntensity Duration Frequency (IDF)

To get the intensity of the rain in a period of 1 hour of maximum daily rainfall data used the formula mononbe.

Table 7, the calculation of the intensity of the rainfall.

Duration (minutes)	Reset Period			
	2 Year	5 Year	10Year	25 Year
	76.458	90.891	97.746	104.334
5	138.93	165.16	177.62	189.59
10	87.52	104.04	111.89	119.43
15	66.79	79.40	85.39	91.14
20	55.13	65.54	70.49	75.24
45	32.11	38.17	41.05	43.82
60	26.51	31.51	33.89	36.17
120	16.70	19.85	21.35	22.79
180	12.74	15.15	16.29	17.39
240	10.52	12.50	13.45	14.35
300	9.07	10.78	11.59	12.37

From table7. above can be made curve Intensity Duration Frequency (IDF) as shown below.

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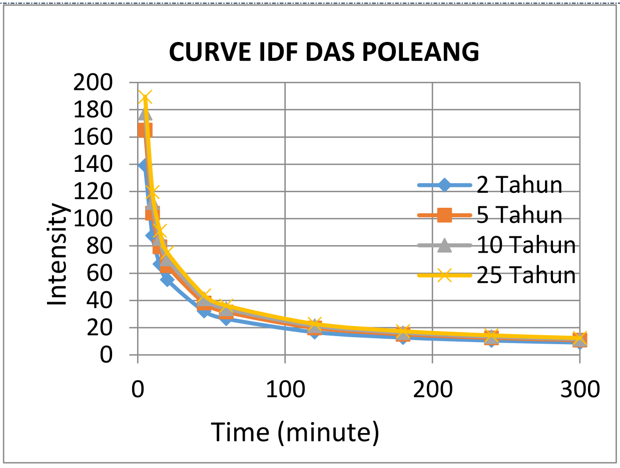

Figure 2. IDF curve (Intensity Duration Frequency)

Time Concentration
Main Length In the poleang basin is 84 km and the slope of the land is 0.01 so that the conservation time of the Poleang watershed is:

$$t_c = \frac{0{,}06628 \times 84^{0.77}}{0{,}01^{0{,}385}}$$
$$= 11{,}833\ Hours$$

In the case of rainy rain is the same as the time of the presentations (tc). As long as the intensity of each period in the Poleang watershed can be seen in the following figures:

Table 8. Intensity relation with retest.

No.	Realiberate (Year)	Rainfall (mm)	Intensity (mm/h)
1	2	76.458	5.105
2	5	90.891	6.068
3	10	97.746	6.526
4	25	104.334	6.966

CoefficientRunoff (C)
CoefficientRunoffBased on Slopes
In determining the runoff coefficients based on the slope in the Poleang basin, the required data is the SRTM DEM (Digital Elevation Model) data as the primary input processed by using ArcGIS 10.3 software.

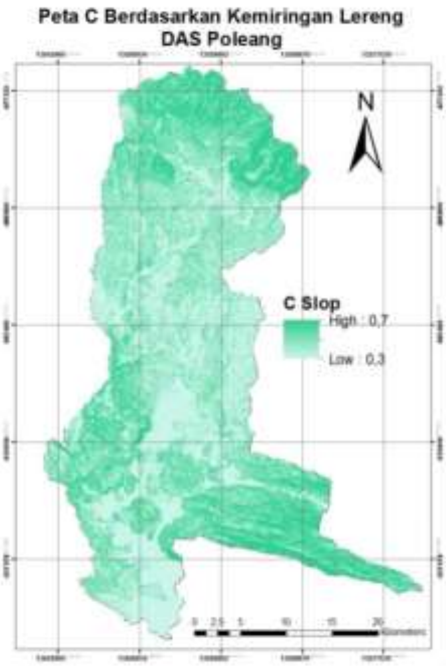

Figure 3. The runoff coefficient based on the slope of the slopes.

The Runoff' Based On Land Cover
Grid-based Runoff coefficient folder making land cover (cover C) made using the Basemap Indonesia (RBI) Digital 1:50000 scale ex. BIG (Geospatial Information Agency).

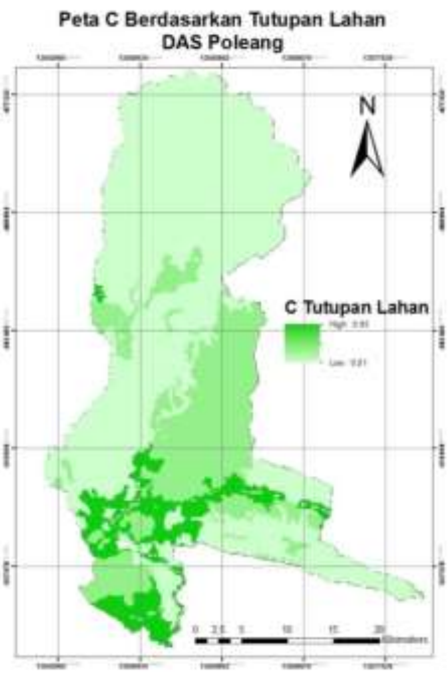

Figure 4. Coefficient of runoff based on land cover

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Average CoefficientRunoff

The average nilebe of the average coefficient is obtained by using equation (2) (C1 + C2) / 2 where C1 is a two-phase coefficient based on the slope of the slope (C slope) and C2 is a non-hydrocaro-coefficient based on aland cover (C slope).

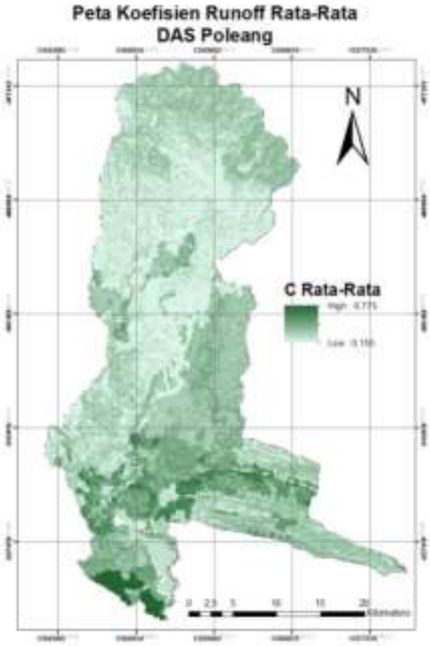

Figure 5. Map of the average coefficient of the Poleang basin

Stream Flow Estimation

Based on the various data that have been obtained on the calculation of the flow rate of the Poleang River Basin with its international methods,

Q = 0.278. C.I.A

Table 9. Recapitulation of discharge value for each re-time

Realiberate	Debit (m^3/sec)
2 years	377,05
5 years	448,17
10 years	482,00
25 years	514,49

Stream Flow Estimation At Sub Poleang Sub

The use of the national biomass is used to calculate the flow discharge of small catch catchments (DAS). Some of the areas where the watershed less than 2.5 km2 can be considered as small watersheds (Ponce, 1989).

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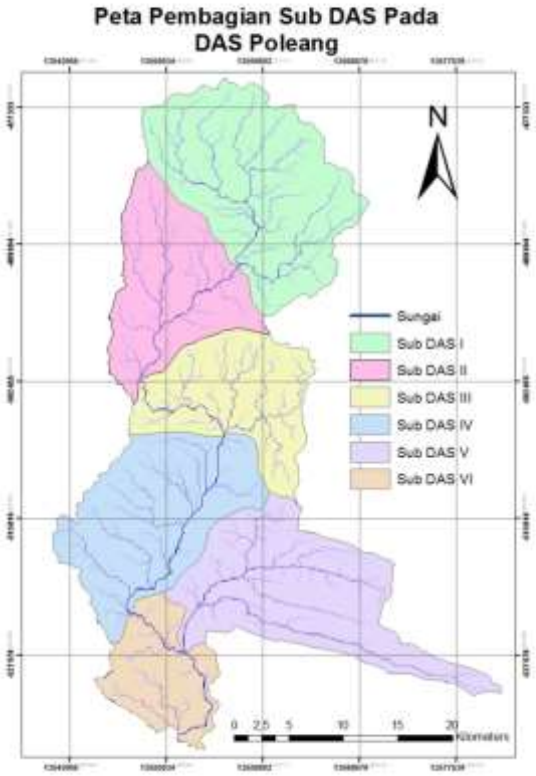

Figure 6. Subdivision of Sub-watersheds in Poleang Watershed

The next is to return the calculation of the time to specify the intensity by using the broad parameter and the length of the respective sub-basins while the C value (Coefficient of Runoff) is the same as the width of the counted DAS.

Table 10. Result of the calculation of flow debit at Poleang Sub DAS

Sub DAS	A (Km^2)	I (mm/h)	Q (m^3/sec)
I	255.23	13.645	210.19
II	163.09	13.748	211.73
III	147.67	19.525	175.83
IV	205.28	13.892	195.86
V	225.54	11.063	201.79
IV	93.53	15.338	127.53
Total	1090.34		1122.93

Based on table10, it can be seen that the total discharge for a 25 year re-birthday in the Poleang watershed is 1122.93 m3 / ds and for the previous calculation is 514.49 m3 / s.

Subsequent to Sub Watershed I returns to the sub-watershed to compare the flow rate of the smallewatersheds.

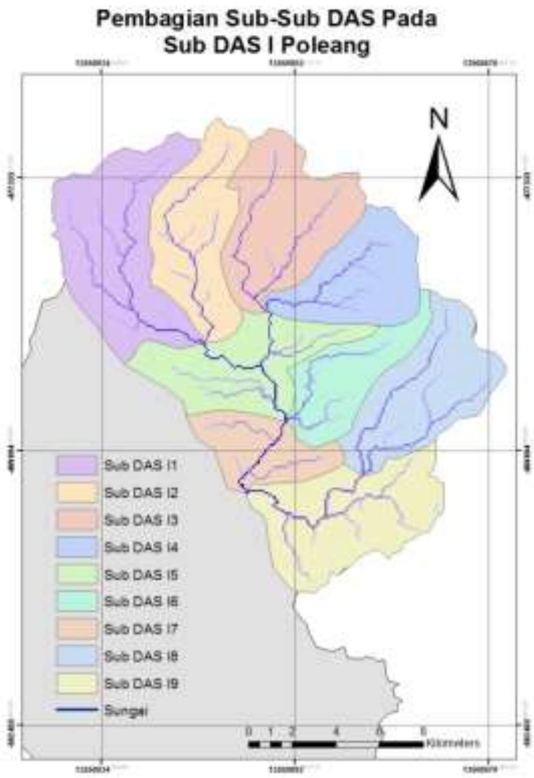

Figure 7. Subdivision of Sub-watersheds in Sub-watershed I PoleangTabel11. Result of the calculation of flow debit at I Poleang Sub-watershed.

Sub DAS I	A (Km^2)	I (mm/h)	Q (m^3/sec)
1	40.54	18.110	45.41
2	28.84	13.748	25.86
3	33.12	19.525	44.64
4	24.1	21.382	34.55
5	28.05	27.422	40.96
6	18.97	22.550	25.84
7	16.08	31.805	22.98
8	30.38	20.654	41.93
9	35.14	20.406	35.16
Total	255.22		317.33

By table11. the total discharge obtained for sub-watershed I is 317.33 m3 / dsedpadata 4.12 the value of the discharge for sub watershed I is 210.19 m3 / s.

V. CONCLUSIONS AND RECOMMENDATIONS

Based on the data that has been obtained and the success of the initialisism can be concluded that thewasololistributionofthe rainfall for the Poleang watershed belongs to the Log Pearson Type III logs whereas the projected rains are for the 2 year reframe of 76.440 mm , the 90th anniversary of 90.861mm, the 10th anniversary of 97.714 mm, and the 25th birthday of 104,300 mm.

The time it takes to rain to walk the far (upstream) point to the local watershed level or the time of the consentation on the Poleang watershed is 11.83 hours. So the flow rate obtained in the Poleang watershed for the 2nd anniversary is 377,05 m3 / s, the 5 year re-birthday is 448,17 m3 / s, the 10 year re-time is 482,00 m3 / s, and the 25 year re is 514,49 m3 / s .

In the division of the watershed the poleang into 6 sub watershed total discharge obtained on the 25th anniversary is 1,122,93 m3 / s while previously based on the previous calculation (without subdivision division) the debit value obtained is only 514,49 m3 / s. Then sub watershed I was subdivided into 9 sub sub-catchments, total discharge was 317,33 m3 / sec whereas in the previous calculation (on sub division of 6 sub watershed) the value of debit at sub watershed I was 210,19 m3 / s. This suggests that the method used to estimate the discharge (rational method) in the Poleang basin is wrong.

VI. ADVICE

1. the more optimal to get results then it takes some of the soil type and additional parameters such as the ilfiltrasi parameter can also affect large small debit.
2. use of the spatial data has iresolusi the higher (meeting) to the results of the analysis can be more accurate and appropriate conditions in field.
3. The use of rational methods only for the area of catchment (DAS) small IE < 2.5 km2

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