The Influence of Basin Landuse Coverage to Flood Hazard at Kemoning River, Kabupaten Sampang

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Abstrak— Sampang adalah salah satu kabupaten di Jawa Timur, yang setiap tahun sering mengalami banjir dan memburuk akhir-akhir ini. Salah satu penyebab banjir sampang adalah tidak terkontrolnya penggunaan lahan di Daerah Aliran Sungai (DAS) Kemoning. Tujuan dari penelitian ini adalah untuk menghitung pengaruh penggunaan lahan DAS terhadap limpasan sungai Kemoning. Penelitian ini menggunakan rumus Q = 0,002778 x Luas x Koefisien x Curah hujan. Penggunaan curah hujan periode 25 tahunan distribusi Log Pearsson III karena telah memenuhi syarat. Hasilnya yaitu Q = 32.86, menggambarkan bahwa semakin tinggi koefisien dapat menyebabkan tingginya debit banjir. Pemerintah Kabupaten Sampang harus menambah area dengan koefisien yang kecil (area hutan) untuk mengurangi debit banjir.

Kata Kunci—Penggunaan lahan DAS, Debit Banjir, Sungai Kemoning, Banjir Sampang

***Abstract*— Sampang is one of East Java's district, which often flooded annually and worsened lately. One of the causes Sampang flood is uncontrolled landuse basin in the watershed (DAS) of Kemoning Rivers. The objective of the research is to calculate the influence of landuse basin coverage to runoff Kemoning River and flood discharge. This research use formula Q = 0,002778 x Large x Coeffisien x Rainfall. 25th return period of rainfall from Logpearson III distribution is used because the distribution is eligible. The results, Q = 32.86, indicate that a higher coefficient can cause an amount of flood discharge. Sampang local government should increase the areas with a small coefficient (The forest area) to reduce amount of flood discharge.**

Keywords—*Landuse Basin, Flood Discharge, Kemoning River, Sampang Flood.*

I. Introduction

Flooding is defined as a state, where the water can not accommodated by the river, causing runoff or puddles on the land should be dry [1].

The most dominant causes of flooding is the runoff increase significantly. Runoff increase more because of landuse changing. A forest can store a large of runoff but in some region (rural and urban area) there are land conversion from forest to settlements. Settlements have small runoff resistance. This is because no catchment area on settlements. As the results of land conversion are an increasing runoff and discharge. Increasing runoff and discharge because the vegetation as a barrier runoff has been lost. Forest area, capable of keeping a large number of water, can decrease of flood [2].

Sampang is one of East Java's district, which often flooded annually and worsened lately. The floodplains of Sampang regencies are an area downstream of the Kemoning basin. There are 7 floodplains in Kabupaten Sampang i.e Banyuanyar District, Dalpenang District, Gunung Sekar District, Karangdalem District, Rongtengah District, Polagan District, and Tanggumong District [3].

Sampang flood causes by a large number of rainfall, morphology of Kemoning River, cross section Kemoning River and drainage system can not accommodate the flood discharge [4].

Moreover, the changing of landuse especially since 2004 to 2013 has resulted to increase the runoff coefficient and flood discharge. Increasing runoff coefficient, especially in the rainy season, can make flood at downstream Kemoning River and contribute to environmental damage [5].

Management landuse is one alternative in integrated flood management to reduce the amount of runoff. Based on Bappeda (Agency for Regional Development), There are not studies about the influence of landuse to runoff especially at Kemoning Basin. The previous studies or researchs concern about drainage systems, community participation, critical disaster areas, and the capacity of reservoirs [4].

The objective this research to analyzed the effect of landuse changing of upstream Kemoning River to the amount of flood discharge.

II. Method

This research use formula Q = 0,002778 x Large x Coeffisien x Rainfall [6]. 25th return period is choosen for the rainfall.

The first steps are collecting maximum precipitation data and analysis average rainfall area. Precipitation

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data is collected by secondary data from Department of Public Works of Water Resources at Kabupaten Sampang [7].

Calculating average rainfall area use polygon Thiessen method. This method to analyzed the coefficient of each station to represent the area of rain station.

The Second step is calculating return period using the frequency and probability of precipitation analysis. This research uses Log Pearson III Distribution and Gumbel Distribution. We should calculated standard deviation from each distribution before we calculate T-year return period rainfall.

We must use Chi Square test to choose the eligible distribution. There is qualified to determine eligible distribution. Gumbell distribution is eligible if the value coefficient of Skweness (Cs) $\leq$ 1,1396 and the value coefficient of curtosis (Ck) $\leq$ 5,4002. Log Persson III distribution is eligible if the value coefficient of Skweness (Cs) and the value coefficient of curtosis (Ck) $\neq 0$ [7].

The last is analysis the influences of land use towards the amount of flood discharge using the formula. The result of the calculation period T of the distribution selected can be used for the formula to determine the effect of land use on the discharge and flooding.

III. Results and Discussion

3.1 Analyze average rainfall area.

Kemoning basin is one of basin at Sampang that has covering area 408.25 km^2 with 9 sub basin and 5 rainfall stations. Rainfall stations are used to calculate maximum precipitation. A mount of maximum precipitation at Kemoning basin can be calculated by the coefficient of the rain station area which it use polygon Thiessen method. Calculating the section area of the flow of flood control, each of the area is influenced by rainfall observations, are using hydrological map.

There are two ways to create polygon Thiessen. They are using manual drawing or using ArchGis Programme. In the hydrological map, created Thiessen polygons, draw a relationship line between the stations, and then draw a line between the axis of the lines connecting these stations..

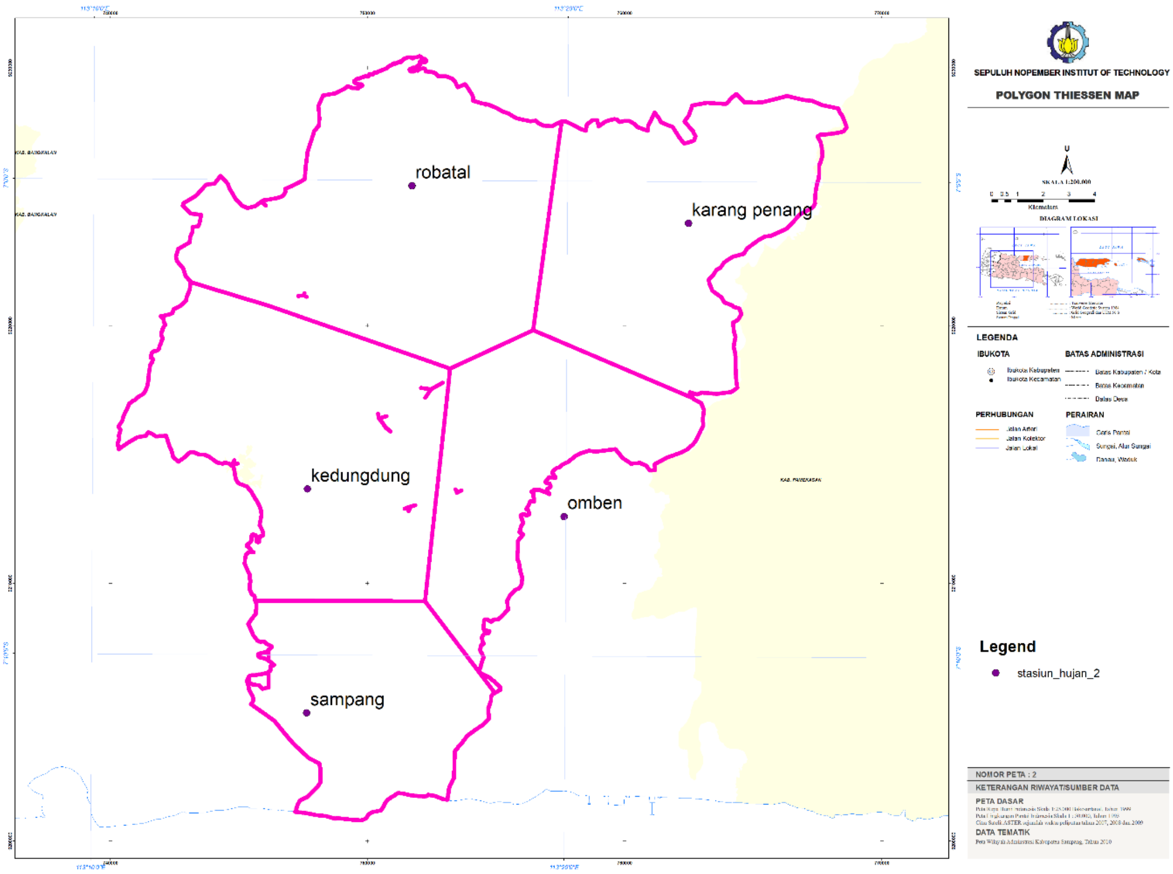

Figure 1 Polygon Thiessen Map

This research Use ArcGis 10.1 Program to draw polygon Thiessen polygon and to compute coeffisien rainfall area. Thiessen polygon are shown in figure 1 and table 1.

TABLE 1 THE COEFFISIEN OF STATION RAINFALL AREA

Area			Coeffisien
Karangpenan	88.2	Km2	0.20989
Omben	62	Km2	0.14754
Kedungdung	101.3	Km2	0.24105
Sampang	57.59	Km2	0.13703
Robatal	111.15	Km2	0.2645
Total	420.24	Km2	1

The result of coeffisien rainfall area is multiplied with the maximum rainfall data to generate avarage rainfall area which is used for Gumbel and Log Pearsson III distribution (shown table 2).

TABLE 2 THE AVARAGE RAINFALL AREA

Nmb	Year	Rainfall station										Total
		Karangpenang		Omben		Kedungdung		Sampang		Robatal		
		Coeff 0.21		Coeff 0.15		Coeff 0.24		Coeff 0.14		Coeff 0.26		
		Data	Data x Coeff	Data	Data x Coeff	Data	Data x Coeff	Data	Data x Coeff	Data	Data x Coeff	
1	2000	135.68	28.48	82.00	12.10	150.00	36.16	67.00	9.18	185.00	48.93	134.84
2	2001	71.41	14.99	73.78	10.88	30.00	7.23	59.00	8.08	37.00	9.79	50.97
3	2002	157.10	32.97	169.00	24.93	160.00	38.57	75.00	10.28	197.33	52.19	158.94
4	2003	64.27	13.49	85.00	12.54	50.00	12.05	51.00	6.99	30.00	7.93	53.01
5	2004	85.69	17.99	70.00	10.33	32.00	7.71	76.00	10.41	39.47	10.44	56.88
6	2005	135.68	28.48	93.00	13.72	50.00	12.05	51.00	6.99	0.00	0.00	61.24
7	2006	59.00	12.38	141.00	20.80	60.00	14.46	51.00	6.99	0.00	0.00	54.64
8	2007	142.00	29.80	53.00	7.82	43.00	10.37	132.00	18.09	88.00	23.28	89.35
9	2008	72.00	15.11	53.00	7.82	161.00	38.81	71.00	9.73	75.00	19.84	91.31
10	2009	131.00	27.49	115.00	16.97	30.00	7.23	64.00	8.77	35.00	9.26	69.72
11	2010	73.00	15.32	48.00	7.08	80.00	19.28	89.00	12.20	45.00	11.90	65.79
12	2011	47.00	9.86	67.00	9.88	69.00	16.63	41.00	5.62	43.00	11.37	53.37
13	2012	48.00	10.07	78.00	11.51	44.00	10.61	71.00	9.73	42.00	11.11	53.03
14	2013	162.00	34.00	49.00	7.23	82.00	19.77	82.00	11.24	78.00	20.63	92.86
15	2014	47.00	9.86	68.00	10.03	80.00	19.28	58.00	7.95	48.00	12.70	59.82
16	2015	57.00	11.96	98.00	14.46	75.00	18.08	73.00	10.00	50.00	13.22	67.73

3.2 Analysis of The Frequency And Probability Of Precipitation. There are many distribution to calculate T-year return period [8]. This research just using two distribution to calculate the frequency and probability of precipitation. The distribution are :

1. Gumbel Distribution

TABLE 3 CALCULATION GUMBELL METHOD

No.	Tahun	X	X - Xr	$(X - Xr)^2$	(X-Xr)3	(X-Xr)4
1	2000	134.84	59.00	3481.01	205379.64	12117411.44
2	2001	50.97	-24.87	618.49	-15381.62	382533.40
3	2002	158.94	83.10	6905.73	573871.69	47689166.31
4	2003	53.01	-22.84	521.61	-11912.95	272077.35
5	2004	56.88	-18.97	359.68	-6821.29	129366.60
6	2005	61.24	-14.61	213.33	-3115.90	45510.52
7	2006	54.64	-21.21	449.73	-9537.38	202257.77
8	2007	89.35	13.51	182.46	2464.63	33291.75
9	2008	91.31	15.46	239.10	3697.13	57168.04
10	2009	69.72	-6.12	37.50	-229.65	1406.30
11	2010	65.79	-10.06	101.18	-1017.71	10236.87
12	2011	53.37	-22.47	504.92	-11345.80	254945.30
13	2012	53.03	-22.82	520.65	-11879.89	271071.24
14	2013	92.86	17.02	289.68	4930.37	83914.91
15	2014	59.82	-16.02	256.62	-4110.89	65853.93
16	2015	67.73	-8.12	65.86	-534.46	4337.29
Total		**1213.51**		**14747.54**	**714455.92**	**61620549.01**

a. Standard Deviation of Gumbel distribution.

$$\sigma = \sqrt{\frac{\sum(x - x_r)^2}{n - 1}} \qquad 1$$

σ = 31,36

Note: σ = standard deviation; X = variance on year, X_r = value avarage rainfall (table 2), n = a number of data.

b. The frequency factor

$$K = \frac{Yt - Yn}{Sn} \qquad 2$$

K = The frequency factor; Yt = Reduced variate as a function of The T-period Yt = -Ln [-Ln (T-1)/T]; Sn = Reduced standard deviation. Yn = 0.5157 dan nilai Sn = 1.0316

TABLE 4 T-YEAR RETURN PERIOD GUMBELL DISTRIBUTION

T year	Yt	K	Xt(mm)
2	0.36650	-0.14463	71.3092
5	1.49997	0.95412	105.7611
10	2.25040	1.68156	128.5704
25	3.19857	2.60069	157.3901
50	3.90197	3.28254	178.7700
100	4.60018	3.95936	199.9921
200	5.29584	4.63371	221.1368
500	6.21364	5.52340	249.0333
1000	6.90729	6.19580	270.1169

c. T-year return period rainfall

$$Xt = Xr + (K.\sigma) \quad (3)$$

Note, Xt = T period Rainfall; Xr = average rainfall. The result of the calculation T-year return period Gumbell method are shown in table 4.

2. Log Pearsson III Distribution

TABLE 5 CALCULATION LOG PEARSSON III

Tahun	Xi	Log Xi	(Log X-Log Xi)	$(Log X - Log Xi)^2$	$(Log X - Log Xi)^3$
2000	134.84	2.1298323	-0.39159082	0.15334337	0.003605745
2001	50.97	1.7073541	0.03088739	0.000954031	8.68336E-10
2002	158.94	2.2012466	-0.46300511	0.214373728	0.009851779
2003	53.01	1.7243198	0.01392172	0.000193814	7.28043E-12
2004	56.88	1.7549522	-0.0167107	0.000279247	2.17755E-11
2005	61.24	1.7870228	-0.04878136	0.002379621	1.34748E-08
2006	54.64	1.7374891	0.00075233	5.66E-07	1.81322E-19
2007	89.35	1.9511039	-0.21286247	0.045310431	9.30239E-05
2008	91.31	1.9605039	-0.22226237	0.049400563	0.000120558
2009	69.72	1.8433597	-0.1051182	0.011049835	1.34917E-06
2010	65.79	1.8181298	-0.07988836	0.006382151	2.59957E-07
2011	53.37	1.7273273	0.01091419	0.00011912	1.69024E-12
2012	53.03	1.724493	0.01374852	0.000189022	6.75361E-12
2013	92.86	1.9678481	-0.22960664	0.052719207	0.000146523
2014	59.82	1.7768811	-0.03863961	0.001493019	3.3281E-09
	1145.78	27.811864	-1.73824148	0.538187725	0.013819256

a. The average of data

$$\overline{\log X} = \frac{\sum \log X}{n} \quad (4)$$

$\overline{\log X} = 1{,}738$

Note : $\overline{\log X}$ = the average data of logarithm; $\sum \log x$ = a mount of value logarithm; n = a number of data

b. Standard deviation of Log Pearsson III distribution

$$\overline{S \log X} = \sqrt{\frac{\sum\left(\log X - \overline{\log X}\right)^2}{n-1}} \quad (5)$$

$\overline{S \log X} = 0{,}8194$

c. Coefficient of Skewness

$$Cs = \frac{n\sum_{i=1}^{n}(\log X - \overline{\log X})^3}{(n-1)(n-2)\left(\overline{S \log X}\right)^3} \quad (6)$$

Cs = 0,3156

Cs = 0.135559 and the value of factor Gt for the Log Pearson III distribution Return Period can be calculated in the interpolation in the table 6.

TABLE 6 INTERPOLATION OF Gt VALUE

	2	5	10	25	50	100	200
Cs 0.1	-0.017	0.836	1.292	1.785	2.107	2.400	2.670
Cs 0.2	-0.033	0.830	1.301	1.818	2.159	2.472	2.763
	-0.016	-0.006	0.009	0.033	0.052	0.072	0.093

d. T- year return periode ranfall

$$Log\ Rt = Log\ X + Gt * S\ Log\ X \quad (7)$$

The result of calculating the distribution shown by table 7

TABLE 7 T-YEAR RETURN PERIOD LOG PEARSSON III DISTRIBUTION

T-year	KT	Log Rt	Rt
2	0.0893105	1.75515849	56.91
5	0.8758664	1.90414635	80.19
10	1.2322003	1.97164241	93.68
25	1.5657346	2.03481981	108.3
50	1.7614909	2.07189957	118
100	1.9216028	2.10222764	126.5
200	2.4507346	2.20245474	159.4

3.3 Chi-Square test

The chi square test are used to determine the rainfall. The result of the calculation shown on Table 8. The coefficient of skweness formula for Gumbell Distribution

$$Cs = \frac{\frac{n}{(n-1)(n-2)} \sum_{i=1}^{n} (Xi - \overline{X})^3}{Sd^3} \quad 8$$

Cs = 1,7657

b. The coefficient of kurtosis formula for Gumbell Distribution

$$Ck = \frac{n^2 \sum_{i=1}^{n} \left(Xi - \overline{X}\right)^4}{(n-1)(n-2)(n-3)\, Sd^4} \quad 9$$

Ck = 5,977

TABLE 8 THE CALCULATION RESULT

No	Distribution	Qualifies	The calculation result	Conclusion
1	Gumbell	Cs ≤ 1.1396 dan Ck ≤ 5.4002	Cs = 1.7657 dan Ck = 5.977	Not eligible
2	Log Person III	Cs ≠ 0	Cs = 0.1355	Eligible

Table 8 shows that the qualified distribution is Log Pearsson III Distribution because value of Coefficient of Kurtosis is 0.1355. the conclusion, this research use 25th rainfall period of Log Pearsson III distribution to calculate flood discharge using the formula.

3.4 Analysis the influences of land use for the amount of flood discharge using the formula.

Basin landuse area consist of landuse such as salt ponds, forests (protected forest, production forest and limited production forest), green open space and grass, farms (kebun), settlements, farms (pertanian), and fields. A large landuse on basin Kemoning are fields, farms and settlements. Details of landuse existing can be seen at table 9.

TABLE 9 LANDUSE AND STREAM COEFFICIENT

Nmb	Landuse	Area Km2	C Stream Coefficient	L x C
1	Salt Ponds	2.15	0.2	0.43
2	Protected Forest	1.07	0.03	0.0321
3	Production Forest	8.27	0.05	0.4135
4	Limited Production Forest	0.37	0.05	0.0185
5	Green open space	1	0.1	0.1
6	Farms	14.52	0.2	2.904
7	Settlements	69.12	0.7	48.384
8	Farms	113.15	0.15	16.9725
9	Green open space (grass)	0.12	0.1	0.012
10	Fields	198.48	0.2	39.696
Total Area		408.25		108.9626

Table 9 show that a landuse has a highest coefficient than the other is settlement. The stream coefficient of settlement is 0.7. The smallest coefficient is protected forest (0.003). A stream coefficient indicate some landuse contribute for flood discharge. Table 6 also show that small coefficients have a small area and the high coefficients have a large area.

Flood discharged is calculated by using this formula :

Q = 0,002778 x Rainfall x (Large x Coeffisien)

Q = 0,002778 x 108,34 x 108,962

Q = 32,79 mm^3/s

A higher coefficient can cause a amount of flood discharge. Sampang local government not only should increase the areas that have a small coefficient such us protected forest and production forest but also should reduce the areas that have a high coefficient to reduce amount of flood discharge.

IV. CONCLUSSION

The analysis results indicate that the effect of the increased flooding is the land use with high coefficients. it can be seen from the table 6, the dominant causes of flooding are fields, farms and settlements. It is caused a high coefficient. Sampang local government should increase a number of area that have a small coefficient such us forest area. Increasing forest area can reduce flood discharge and then reduce flood hazard.

REFERENCES

[1] Associated Programme on Flood Management, *Social Aspects and Stakeholder Involvement in Integrated Flood Management*, Geneva: World Meteorological Organization. 2006.

[2] Robert, J.K and Roestam Sjarief, Intergrated Water Resources Management,Yogyakarta : Andi Published. 2008.

[3*]* Regional Disaster Management Agency, The Report of Sampang Flood. Sampang, 2014.

[4].Regional Development Planning Agency., The Study of Grand Design of Basin Kemoning Rive,. Sampang, 2014.

[5],Agus, Eko Kurniawan, Public Participation in Integrated Flood Management of Watershed Kemoning River at Sampang Regency . Thesis, Master of Enviromental Science. Dipenogoro University.Semarang. 2014.

[6]. Bambang,Triadmodjo, The Applied of Hidrologi, Yogyakarta, Beta Offset, 2015.

[7]. Department of Public Works of Water Resources at Kabupaten Sampang, Precipitation Data from 2010 to 2015, Sampang,2015

[8]. Soewarno, Applications Statistical Methods for Data Analysis Hydrology, Yogyakarta:Graha Ilmu.

[9].Regional Development Planning Agency, Spatial Planning for Sampang District.Sampang, 2009.

[10]. Asdak,C. Hidrology and Management Basin, Gajah Mada University Press, Yogyakarta, 2002.