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Analysis of the Effect of Land Use on Flood Discharge in the Pangkajene River Basin, Pangkajene Regency and the Islands

Muhammad Rizal Zainuddin[1], Mary Selintung[2], Rita Lopa[3]
Civil Engineering Study Program, Hasanuddin University Makassar
Email: rizalmuh2023@gmail.com

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Abstract
Changes in land cover that occur have an impact on hydrological conditions in a watershed. The hydrological condition referred to by the amount of watershed output is the discharge which describes the amount of water. This study aims to determine the effect of changes in land cover on river flow in the Pangkajene watershed. Data were analyzed using hydrological analysis and land use change. The results showed that there was an increase in design flood discharge of ±18.83 m³ in each return period. Changes in land use that occur are the area of rice fields, ponds, and settlements increases while the area of forest decreases. The increase in the value of flood discharge is not significant because changes in land use have not changed much either.

1. Introduction

Rapid human growth causes the comparison between population and agricultural land to be unbalanced. This causes the ownership of agricultural land to become increasingly narrow. This situation often encourages some farmers to encroach on forests and other unproductive land as agricultural land. All of this has an impact on the occurrence of critical land which stems from less than ideal land cover by vegetation that is able to withstand erosion. Land cover under conditions of intensive and less conservative ownership and farming methods is one of the problems that are interrelated with erosion and sedimentation (Linsley Jr et al., 1975).

If a variety of trees are cut down in a watershed, this means a reduction in ground cover vegetation and an increase in the area of the exposed area. If there is precipitation, there will be an increase in the hitting power of rainfall, runoff, and erosion will occur. Increased erosion and landslides in the catchment area will eventually increase the sediment load carried by rainwater. Disruption to a watershed ecosystem can vary, especially from the inhabitants of a watershed, namely humans. If the function of a watershed is disrupted, the hydrological system which is the main function of the watershed is disrupted, the capture of rainfall, absorption and storage of water is reduced, or the distribution system becomes wasteful (Lopa & Shimatani, 2013). This event will cause an abundance of water in the rainy season, and vice versa greatly reduced water in the dry season. This causes fluctuations in river discharge between the dry season and the rainy season to differ sharply. So if the river discharge fluctuations are very sharp, it means that the watershed function is not working properly, if this happens it means that the quality of the watershed is low (Lopa, 2012). In terms of rainfall, the watershed area can be divided into 2 (two), namely areas that function as infiltration areas and areas that function as drainage areas. Whether the area functions or not is closely related to land use (Rachmayanti et al., 2022).

Administratively, the Pangkajene watershed is in the Saddang river area (WS) in South Sulawesi Province with a watershed area of 440 km2 and a river length of 30 km. The Pangkajene River functions as a catchment area, a source of raw water, for agricultural and fishery activities. Apart from that, on the Pangkajene River there is also the Tabo-tabo Dam which is located in Tabo-tabo Village (Raudkivi, 2013), Bungoro District, Pangkep Regency, where this dam is a dam that controls the Pangkajene River flood which is capable of providing raw water of 33.34 l/s. Geographically, the Pangkajene River is located between 4°50'55.6” South Latitude – 4°45’40” South Latitude and 119°30’41.4” East Longitude – 119°41’12” East Longitude (Lubis, 2016).

2. Materials and Methods

This research is quantitative descriptive (Lawrence Neuman, 2014). The purpose of this type of research is to make systematic, factual and accurate descriptions, drawings or drawings of the facts, characteristics and relationships between the phenomena studied . The research location is the Pangkajene Watershed for land use changes to flood discharge in Pangkep Regency, South Sulawesi Province.

Figure 1. Map of Research Locations

Data source

In this study, two data sources were used, namely primary data, namely data obtained from the research location, namely topographic maps, hydroclimatological data, forest data, agricultural and plantation data, settlement data, population data, land use change data, the above data were processed. to be used as a reference in determining the flood discharge that occurs due to changes in land use. Secondary data is data obtained from literature or previous research reports about the research location. Besides that, library data was also collected, namely collecting theoretical data, documents, obtained through library books, training, magazines, journals, and other books that were in accordance with the research material (Sudarto & Mukhlisin, 2010).

Data Analysis Techniques

In this study, the flood discharge conditions analyzed were runoff and flow discharge. The data used is data for 10 years from 2009 – 2018. Meanwhile, annual land use data is obtained from the large growth rate of land area per year from 2009 – 2018.

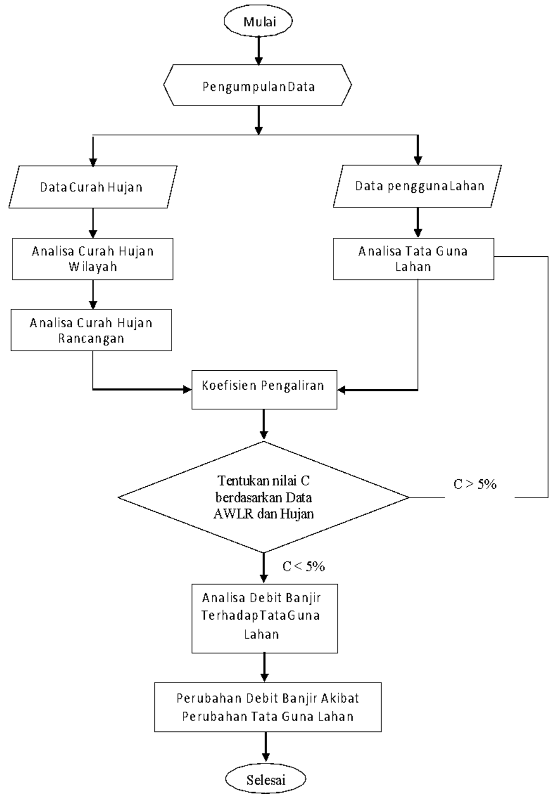

Figure 2. Research Flowchart.

3. Results and Discussions

Pangkajene Watershed Land Use

The development of the population and its activities, the progress of the economy of the people of Pangkep Regency and the influence of advances in technology and information as well as national and global changes encourage changes in the selection of settlement locations and activities, the development of activities and functions of a location and region will ultimately change the use of space (Marasabessy et al., 2020).

Changes in the use of settlement space for housing needs, trade and service buildings, and other settlement equipment occur in line with the population distribution of existing conditions, so that the use of residential space will be more expansive from existing locations.

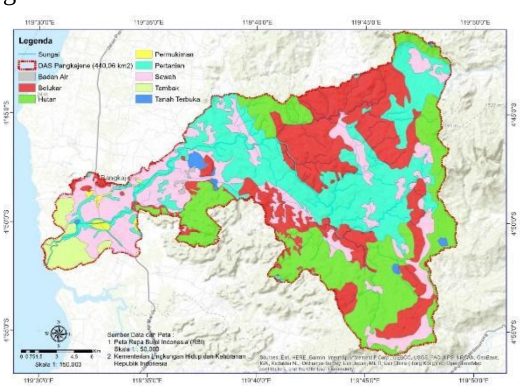

Figure 3. 2009 Pangkajene Watershed Land Use Map

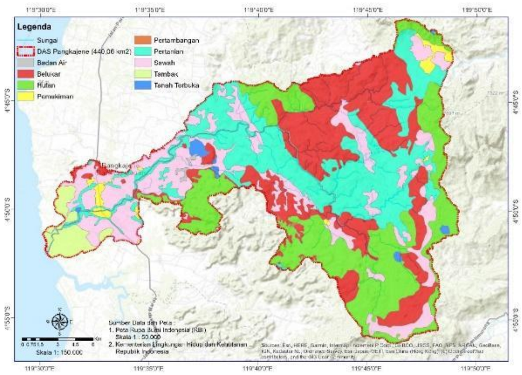

Figure 4. 2018 Pangkajene Watershed Land Use Map

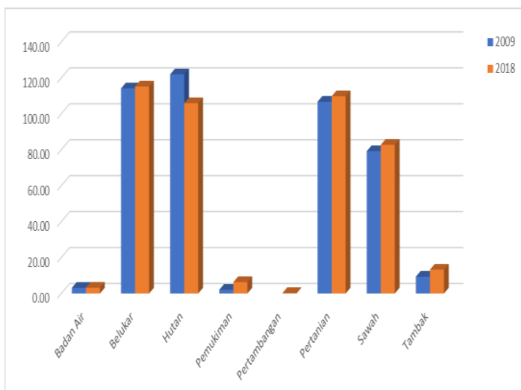

Figure 5. Graph of Changes in Land Use in 2009 and 2018

The results of the analysis of changes in land use in the Pangkajene Watershed in 2009-2018 can be seen in Figure 5, you can see changes in land cover where there has been an increase in land in the Water Body from 3.16 Km² to 3.18 Km², Shrubs 114.10 Km² to 115 .17 Km², Forest 121.94 Km² to 105.88, Residential 2.08 Km² to 6.31 Km², Agriculture 106.73 Km² to 109.72 Km², Rice fields 79.19 Km² to 82.73 Km², Tambak 9, 36 Km² became 13.25 Km², Open Land 3.51 Km² became 3.56 Km², and mining land became new land of 0.24 Km² in the last 10 years.

Regional Average Rainfall

Based on the distribution of rain station locations that affect the Pangkajene watershed, the rain stations used are Tabo-tabo station, Pangkajene station, and Leang Lonrong station. From the results of regional rain analysis using*polygon Teissen*, then the maximum daily rainfall obtained as shown in the table.

Table 1. Average Rainfall in the Pangkajene Watershed Area.

No	Year	Rainfall Max			Will Rain Yes
		Spots - Spots	Group those	Lon two	
Coefficient		0.51	0.38	0.11	
1	2009	152	221	151	178.11
2	2010	102	182	164	139.22
3	2011	275	172	117	218.53
4	2012	115	157	80	127.06
5	2013	77	138	110	103.89
6	2014	55	89	87	71.56
7	2015	56	113	102	82.84
8	2016	74	123	91	94.59
9	2017	108	81	118	99.02
10	2018	140	178	142	154.66

Design Rainfall

Design rainfall is the largest annual rainfall with a certain probability that may occur in an area at a certain return period. In this calculation the design rainfall is calculated using frequency analysis, calculating the statistical magnitude of the relevant data (X, s, Cv, Cs, Ck).

$$X \text{ Average} = \frac{S\ Xi}{n}$$

$$= \frac{1269.49}{10}$$

$$= 126.95 \text{ mm/year}$$

Standard Deviation :

$$Sx = \sqrt{\frac{S\ (Xi - X)^2}{n - 1}}$$

$$Sx = \left(\frac{1929.59}{9}\right)^{0.5} = 46.30$$

Coefficient of Variation :

$$v = \frac{Sx}{\quad} = \frac{46.30}{\quad} = 0,36$$

X 126.95

Coefficient Skewness:

$$Cs = \frac{n}{(n-1)\,(n-2)\,Sx^3} \; S\,(Xi - X)^3$$

$$= \frac{10}{(9)\,(8)\,99252{,}85} \; 601574.85 = 0.84$$

Kurtosis Coefficient :

$$Ck = \frac{n^2}{(n-1)\,(n-2)\,Sx^4} \; S\,(Xi - X)^4$$

$$= \frac{10^2}{(9)\,(8)\,(7)\,4595406{,}82} \; 93005686.25$$

$= 4.01$

Based on these statistical values, the appropriate billing can be estimated.

Quality Statistics:

Normal : Cs = 0 ; Ck = 3

Log Normal : Cs = 3 Cv

Gumbel : Cs = 1,14 ; Ck = 5,4

Log - Pearson Type III : If everything is not there.

Based on the analysis of statistical parameters belonging to the Log distribution type -*Pearson Type III.*

Data is sorted from smallest to largest (or vice versa).

Table 2. Probability Data.

No.	X (mm)	m(n+1)	%
1	82.8444	0.0909	9.0909
2	94.5919	0.1818	18.1818
3	99.0220	0.2727	27.2727
4	103.8946	0.3636	36.3636
5	127.0568	0.4545	45.4545
6	139.2223	0.5455	54.5455
7	154.6600	0.6364	63.6364
8	178.1100	0.7273	72.7273
9	218.5349	0.8182	81.8182
10	0.0000	0.9091	90.9091

Furthermore, it can be estimated that the rain is planned according to the anniversary period that you want to plan and the frequency factor (K) according to the selected distribution. By using the formula X(t) = Xaverage + K . The following Sdevs are obtained by Plan Rain with various return times.

Table 3. Rain Plans With Various Time Repeat

T	T	P(%)	Cs	G	Xt
2	2	50	0.8416	-0.1478	120.1044
5	5	20	0.8416	0.7963	163.8224
10	10	10	0.8416	1.3707	190.4176
20	20	5	0.8416	1.9362	216.5996
25	25	4	0.8416	2.0492	221.8360
50	50	2	0.8416	2.5222	243.7333
100	100	1	0.8416	2.9671	264.3359

Further testing with Chi-squared.

K = 1 + 3.32 log n

= 1 + 3.32 log 10

= 4.32 = 4 Classes

Table 4. Calculation of the Chi Square Test for Log Distribution*Pearson Type III*

No.	Nilai Batas Sub Kelas			Jumlah Data OF	Jumlah Data EF	$(OF - EF)^2$	$(OF - EF)^2 / EF$
1	X	<	25.000	2.000	2.500	0.250	0.100
2	25.000	< X <	50.000	3.000	2.500	0.250	0.100
3	50.000	< X <	75.000	3.000	2.500	0.250	0.100
4	75.000	>	100.000	2.000	2.500	0.250	0.100
Jumlah :				10.000	10.000	1.000	0.400

Flow Coefficient

One of the important concepts in flood analysis is the runoff coefficient (*runoff*) which is usually denoted by C. The coefficient C is defined as the ratio between the peak surface runoff rate and the rainfall intensity (Riswal & Sukri, 2020).

Table 5. Flow coefficient (C)

Land Cover	Coefficient
Forest	0.20
Agriculture	0.5
Check the Bushes	0.22
Plantation	0.475
Ricefield	0.525
Settlement	0.9
pond	0.6
Open Land	0.6

From the results of the analysis, the flow coefficient for land use in 2009 was C = 0.360, the flow coefficient for land use and flow coefficient for land use in 2019 was C = 0.372. The results of the flow coefficient will be used as an evaluation in calculating the design flood as part of the data input in the calculation of effective rainfall.

Analysis of Planned Flood Discharge on Land Use.

To find out changes in flood discharge due to changes in land use in the Pangkajene Watershed, it is necessary to analyze the 2009 and 2018 surface runoff discharges and then make a comparison. In the analysis of the calculation of the planned flood discharge, the method used is the Nakayasu HSS method.

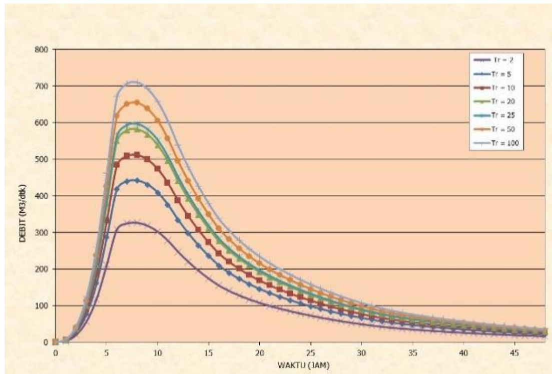

Figure 6. Pangkajene Watershed Flood Hydrograph in 2009

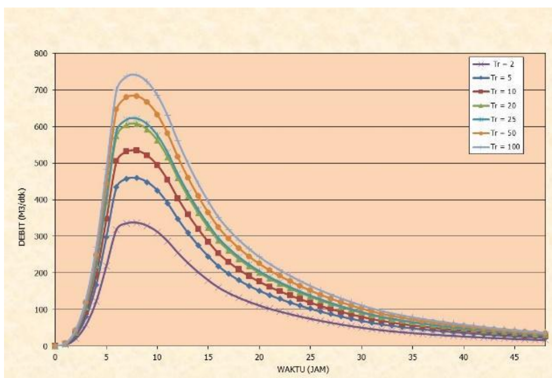

Figure 7. Pangkajene Watershed Flood Hydrograph in 2018

Further, a comparison of the flood debits of the 2009 and 2018 plans was carried out to find out the extent of the influence of land use changes. A recapitulation of the flood debit and the amount of change from 2009 to 2018 can be seen in the table.

Table 5. Maximum Flood Debt Summary and Changes from 2009 to 2018

Periode Ulang	Q 2009	Q 2018	Perubahan	Perubahan
T (Tahun)	m3/det	m3/det	m3/det	%
2	326.60	337.87	11.27	3.45
5	441.29	456.52	15.22	3.45
10	511.79	529.44	17.66	3.45
20	581.74	601.81	20.07	3.45
25	595.74	616.29	20.55	3.45
50	654.13	676.70	22.57	3.45
100	710.18	734.68	24.50	3.45
Rata - Rata Perubahan			18.83	3.45

4. Conclusion

Changes in land use in the Pangkajene watershed caused an increase in the runoff coefficient (C) in 2009 by 0.360 and in 2018 by 0.372. The increase in the value of the flow coefficient will affect the increase in flood discharge. The results of the design flood discharge analysis show that in 2009 and 2018 an increase in flood discharge was obtained by 3.45% or ± 18.83 m3/s in each return period.

It is hoped that there will be similar and ongoing research on this matter, especially in watersheds (DAS) which have a high potential for changing land use into residential areas as a result of the supporting infrastructure development itself.

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