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The Influence of Critical Land to Reduce Flood in Arau Watersheds at Padang City- Indonesia

Lusi Utama, Amrizal, Isril Berd, Zuherna

Abstract

Flood is a natural phenomenon that often occurs. The parameters causing floods are due to high rainfall, changes in land use, illegal logging, damaged drainage and lack of government attention in making policies. The city of Padang from 2008 - 2018 often flooded. Indonesia is a country that has 2 seasons, the dry season and the rainy season. So that the benefits of water can be used for needs, so during the rainy season, this water can be used as a reserve of water in the dry season. From research conducted on the Arau watershed, that there are 8 SUB Arau watersheds experiencing flooding. To reduce the flooding that occurs, critical land is used in each SUB watershed. The calculation of rainfall using rainfall data from 2005 - 2017 and Thiessen theory on rainfall data from 5 stations to get rainfall plans. Water debit calculations use rational formulas. Conservation of degraded land into developed land in the form of green land and forests obtained for the largest area of green land required in the Baringin SUB Watershed and the largest forest area needed in the Lubuk Kilangan SUB Watershed.

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The Influence of Critical Land to Reduce Flood in Arau Watersheds at Padang City-Indonesia

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***Abstract**: Flood is a natural phenomenon that often occurs. The parameters causing floods are due to high rainfall, changes in land use, illegal logging, damaged drainage and lack of government attention in making policies. The city of Padang from 2008 - 2018 often flooded. Indonesia is a country that has 2 seasons, the dry season and the rainy season. So that the benefits of water can be used for needs, so during the rainy season, this water can be used as a reserve of water in the dry season. From research conducted on the Arau watershed, that there are 8 SUB Arau watersheds experiencing flooding. To reduce the flooding that occurs, critical land is used in each SUB watershed. The calculation of rainfall, using rainfall data from 2005 – 2017, and Thiessen theory on rainfall data from 5 stations, has got rainfall plans. Water debit calculations use rational formulas. Conservation of degraded land into developed land in the form of green land and forests obtained for the largest area of green land required in the Baringin SUB Watershed and the largest forest area needed in the Lubuk Kilangan SUB Watershed.*

***Keywords**: Land, Flood,Ccritical, SUB Watershed, Discharge*

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1. Introduction

Flood is a natural phenomenon that often occurs in areas that are often flowed by rivers. Flood is one of the natural disasters and includes events where human activities play a role that causes flooding. Floods often result in the loss of property and lives. The parameters causing floods are due to high rainfall, changes in land use, illegal logging, damaged drainage and the lack of government attention in making policies (Asdak, C, 2010).

Watershed morphometry is a quantitative physical watershed network that is related to watershed geomorphology, which is determined by the watershed area, watershed shape, river network, flow density, flow pattern and gradient of river steepness (Paimin, Irfan Budi, Dewi Ratna, 2012). By knowing the morphometric classification of watershed, the amount of

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water storage will be obtained. This will affect the amount of rain that flows on the surface of the land which causes flooding. A watershed is a gathering place for rain into a river system, which will affect the shape of the river flow pattern. The shape of the watershed will affect the concentration of rain to the outlet. Flow density index illustrates the density of river flow in a watershed. The higher the rate of flow density, the greater the risk of flooding. River flow velocity is influenced by the steepness of the river.

Padang City, located in West Sumatra Province has an area of 694.96 km², with a population of 875,750 (Wahyu D. H, 2012), of which 387,592 people or 44.26% of the population of Padang City are in the Arau Watershed. The area of Batang Arau watershed is 169,031 km² which consists of 13 sub-watersheds. The headwaters of the river are located at an altitude of 1915 m d.p.l, with an upstream watershed area of 30.90 km², consisting of conservation areas, protected forests and community-owned land. The length of the main river and tributaries of Batang Arau is 216.27 km and the length of the main river is 86.66 km. In addition the city of Padang also has high rainfall, an average rainfall of 124 to 183 mm per month. The average annual rainfall is 3,329 mm to 4,296 mm. From the results of the study (Lusi Utama, 2020) in "Land Use Model to Reduce Flood at Arau Padang Watershed" that of the 13 SUB watershed found in the Arau watershed, there were 8 SUB watershed experiencing flooding, namely Padang Idas SUB watershed, Batang Arau SUB watershed, Lubuk Kilangan SUB watershed, Lubuk Paraku SUB watershed, Indarung watershed, Aia Baringin watershed, Luwung watershed and SUB watershed Sekayang Gadang. So that the 8 SUB watershed can be reduced by flooding, can be used critical land in each SUB watershed. Critical land is land that has been damaged, so that its function is reduced both the function of the water system and its production function which results in the land being unable to carry out the process of water absorption (infiltration), so that flooding occurs. Critical land is characterized by damage to soil structure and decreased quality and quantity of organic matter.

In 8 Arau SUB watershed, there is a sufficiently large amount of degraded land, so that this degraded land can be used for repair (conservation), Arsyad, 2006. Conservation is defined as the placement of a parcel of land and treat it according to the conditions needed to avoid damage land again. It was further stated that the conservation effort was aimed at preventing soil damage due to erosion, repairing damaged land, and maintaining and increasing soil productivity so that it could be used sustainably. Conservation has a close relationship with water conservation. Water conservation in principle is the use of water that falls to the ground to regulate the timing of the flow so that there is no flooding that can damage and there is enough water during the dry season.

The techniques or methods of soil and water conservation are divided into three groups, namely: vegetative conservation techniques, in the form of biological conservation techniques, mechanical conservation techniques are also referred to as technical civil conservation techniques; and chemical conservation techniques.

A series of studies aimed at obtaining a soil and water conservation technique that is suitable for land conditions in Indonesia have been carried out by various institutions. One of the institutions that have done a lot of research into soil and water conservation methods is the Center for Research and Development of Soil and Agro-climate (Puslitbangtanah). Conservation research activities at this institution began in 1970. Research conducted includes improving the physical properties of soils, erosion control, and water management.

Research on improving soil physical properties using soil conditioners, (such as asphalt emulsions, polyacrylamide / PAM, and bitumen emulsions) has been conducted by the Center for Research and Development since 1970, however, the results of these studies are difficult to apply at the farm level, because the materials used are difficult obtained and the price is relatively expensive. Therefore, since 1976, research on improving soil physical properties is more directed at the use of easily obtainable natural materials, namely organic material sourced from plant remnants and forage materials from ground cover plants, hedges, strip plants and others, and manure (Dariah et al., 2017). This study uses ground cover plants that can absorb water (large infiltration).

2. Material and Method

The data needed is in the form of flood area and critical area of each SUB Watershed, as well as a map of the earth that is overlayed and analyzed using ARC GIS to get the SUB watershed. Rainfall data from five (5) rainfall recording stations: Batu Busuk Station, Mount Nago, Sarik Mountain, Rice Fields and Simpang Alai. Rainfall data is used from 5 stations from 2005 - 2017. To get the rainfall plan, the Thiessen formula, Gumbel Method, Hasper Method and Wedwen Method are used. Discharge/Debit is calculated according to Rational method: Q = 0,00278 c.I.A. According to the study of Saidi A, (1995), Factors influencing surface flow and sedimentation and their impact on land degradation in the Sumani Solok West Sumatra sub-watershed ", result that the proportion of forest land which is on slopes> 25%, gives the biggest contribution to debit. Forests function to reduce surface runoff and sedimentation. If the proportion of forests in a watershed is on a large slope of 25%, it will affect surface runoff and sedimentation due to the short amount of time for rainwater to enter the ground (infiltration). The nature of forest land is the same as that of green land. For small forest areas there is a reduction in discharge, for this reason it is necessary to reforest. For the proportion of agricultural land (irrigated fields), greatly affects the amount of surface runoff. If the proportion of agricultural land area (irrigation) is larger, resulting in a wider open land area. A large proportion of housing area results in increased surface flow. These factors will be taken into account to determine the area of critical land needed to reduce flooding. Wahyu DH, (2012) in "Analysis of Watershed Problems in Batang Arau, Padang City, West Sumatra Province". Due to the decrease in the area of rice field cover there is a tendency for an increase in maximum discharge, so that the overall function of the paddy field as a barrier to surface flow decreases, and causes a decrease in infiltration resulting in increased surface flow. Aprizon P, (2013), in "Analysis of Flood Disasters in Padang City (Case Study of Rainfall Intensity 1980 - 2009 and Geomorphological Aspects)" Journal of Resources and Coastal Vulnerability Research, Agency for Marine and Fisheries Research and Development, Ministry of Maritime Affairs and Fisheries which results in land and slope causes flooding. From the results of Lusi Utama's study, 2020 in the "Land Use Model to Reduce Flood at Arau Padang Watershed", that the magnitude of the flood occurred is as follows:

Table 1. Debit flood 8 SUB Watershed Arau

SUB DAS Name	Large flood (m^3/second)
Batang Arau	0,56
A.Padang Idas	4,81
Lubuk Kilangan	15,47
Lubuk Paraku	6,32
Indarung	10
Aia Baringin	6,47
A.Luwung	7,88
Sekayang Gadang	1,52

So that the 8 SUB DAS can be reduced by flooding, use critical land by turning it into built up land. For the management of degraded land, an earth map that is overlayed using the ARC GIS program, obtained the critical land area in each sub-watershed is listed in Table 2. as follows:

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Table 2. Critical Land Area of Arau Watershed

No	SUB DAS Name	Land Critism	Area (ha)
1	Aia Baringin	Critical potential	253,83
		Not critical	354,50
2	A.Luwung	Critical potential	235,49
		Not critical	498,74
3	A.Padang Ideas	Critical potential	49,99
		Not critical	720,40
4	Bt. Arau	Not critical	2314,12
5	Lubuk Kilangan	Rather critical	285,34
		Critical potential	2563,27
		Not critical	297,64
6	Lubuk Paraku	Rather critical	174,19
		Critical potential	1896,64
		Not critical	789,05
7	Indarung	Rather critical	60,64
		Critical potential	1362,31
		Not critical	1143,61
8	Sekayang Gadang	Not critical	338,08

Table 3: Percentage of Critical Land Area

No	SUB DAS Name	Land criticality	Area (ha)	% critical land	% total critical land
1	Aia Baringin	Critical potential	253,83	1,334	1,334
		Not critical	354,50	-	-
2	A.Luwung	Critical potential	235,49	1,238	1,238
		Not critical	498,74	-	-
3	A.Padang Idas	Critical potential	49,99	0,263	0,263
		Not critical	720,40	-	-
4	Batang Arau	Not critical	2314,12	-	-
5	Lubuk Kilangan	Rather critical	285,34	1,5	-
		Critical potential	2563,27	13,47	14,97
		Noot critical	297,64	-	-
6	Lubuk Paraku	Rather critical	174,19	0,916	10,888
		Critical potential	1896,64	9,970	-
		Not critical	789,05	-	-
7	Indarung	Rather critical	60,64	0,319	
		Critical potential	1362,31	7,161	7,480
		Not critical	1143,61		
8	Sekayang Gadang	Not critical	338,08	-	-

3. Results and Discussion

Area percentage of degraded land will be used as non-critical land (conservation land), is vegetative conservation. As has been proven in Saidi A research (1995, by conserving critical land into vegetative land in the form of green land, forests and irrigated fields). From table 3. there are 2 (two) sub-watersheds that do not have critical land, namely Batang Arau, and Sekayang Gadang, and 6 sub-watersheds that have critical land. For the 2 SUB watershed, namely SUB watershed of Arau and Sekayang Gadang, the flood that occurred was small, namely Arau flood debit of 0.56 m3 / sec and Sekayang Gadang 1.52 m3 / sec ((Table 1). Then the 2 SUB watershed were not converted to critical land use. 6 SUB watershed that have degraded land are converted to degraded land into infiltrated / built land to reduce flooding as follows:

Table 4. Debit with conversion of degraded land to developed land

SUB DAS Name	% critical land	Intensity(mm /hour)	Area (ha)	C (coefficient) Green land C =0,15 Forest C = 0,20	Discharge/ Debit Q = 0,00278 c I.A m3/second
A.Padang Idas	0,263	10,31	49,99	C=0,15	0,22
Lubuk Kilangan	14,97	10,30	2848,61	C = 0,20	16,31
Lubuk Paraku	10,888	7,60	2070,83	C = 0,20	8,75
Indarung	7,480	12,17	1422,95	C = 0,20	9,63
Aia Baringin	1,334	13,82	253,83	C = 0,15	1,46
A. Luwung	1,238	14,67	235,49	C = 0,15	1,44

Table 5. Debit for use of critical land to reduce flooding

No	Sub DAS Name	Flood discharge that occurs (m3/second)	Discharge from use of critical land (m3/second)
1	A. Padang Idas	4,81	0,22
2	Lubuk Kilangan	15,47	16,31
3	Lubuk Paraku	6,32	8,75
4	S. Indarung	10	9,63
5	Aia Baringin	6,47	1,46
6	A. Luwung	7,88	1,44
	Total	50,95	37,81

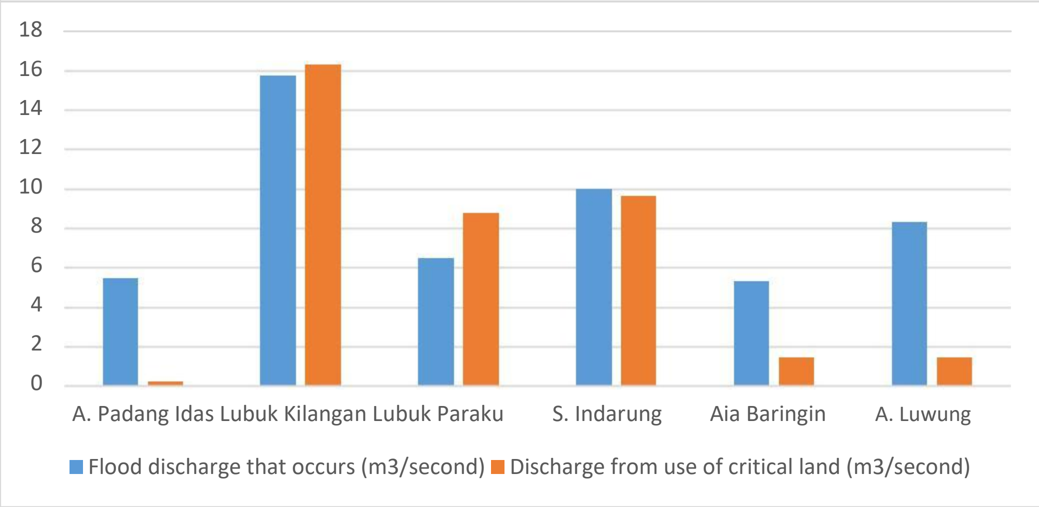

Figure 1. Chart of debit of critical land use to reduce flooding

From Table 5 and figure 1, it can be seen that the amount of discharge caused by the use of critical land is 37.81 m^3/second. The amount of discharge 37.81 m^3/second, provides a reduction in flooding, so that if the use of critical land is always done it is expected that the Arau Watershed is safe from flooding

4. Conclusions

a. There are 6 SUB watershed which have the biggest flood.

b. From the use of degraded land with vegetative conservation systems which means by converting degraded land to green land, forests and irrigated rice fields, resulting from 6 SUB Watershed that flooded to only 3 SUB Watershed that has been flooded.

c. There are 3 Sub Watershed still flooding are: Padang Idas, Aia Baringin and Luwung.

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