Study on Watershed Characteristics to Restore Carrying Capacity of Watershed Batulicin in South Kalimantan Province

by Eko Rini Indrayatie

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ABSTRACT

Watershed Batulicin South Kalimantan Province is a watershed with handling priority in Indonesia (Ministry of Forestry Decree No. SK. 328 / Menhut-II / 2009). In Government Regulation No. 37 Year 2012 on Watershed Management it was stated that the priority watershed is the watershed whose carrying capacity needs to be restored. Floods in South Kalimantan province including in Watershed Batulicin in the period from 2007 - 2010 was increasing.

Based on those facts mentioned above, it is necessary to carry out a study on controlling flood vulnerability in Watershed Batulicin. The purposes of this study were to find out the characteristics of watershed hydrology that became the parameters to determine the flood vulnerability level, and as a reference to determine the direction of policy priorities of Watershed Batulicin management, in order to obtain optimal results for flood control.

It was a descriptive quantitative study, providing a spatial overview of watershed characteristics, which was measured quantitatively. This study used a watershed ecological region approach, where the analysis process and the presentation were conducted spatially.

The results of the study indicated that the characteristics of watershed comprised of: a) the shapes of the watershed consisting of two rounded sub-watersheds and five elongated sub-watersheds; b) the dendritic drainage pattern; c) the river networks, namely 3 lower density sub-watersheds and 4 medium density sub-watersheds; d) the land covers dominated by 33.1% of secondary dryland forest, 23.6% of dry-land agriculture and 14.1% of plantation, e) coefficient of river regime in 1995 - 2004 between 1:2 to 1:15, and in 2014 1:21, f) very critical land of 8,257.44 ha (5.78%).

Keywords: Watershed, Characteristics, Flood

INTRODUCTION

The characteristics of watershed such as barren land, critical land, erosion on steep slopes used either for agriculture or for other uses such as settlement and mining, have gained government's attention. However, the degradation process keeps continuing in the absence of integrated acts and efforts executed by the sectors or parties having interests in the watershed. The forest damage becomes the cause of the decline of watershed quality. Furthermore, the ecosystem's stability is disrupted and then results in negative impacts on the role of the forest as the buffer of life including in maintaining the stability of water system giving impacts on

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the surface water runoff, which is greatly affecting the amount of erosion and the frequency of flood (Fiener, et al., 2007).

Watershed can be viewed as a natural system hosting biophysical-hydrological processes or complex socio-economic and cultural activities of community. The damage of watershed hydrological condition as the result of the cultivated area expansion and uncontrolled settlement, regardless the principles of water and soil conservation often becomes the cause of the increase in erosion and sedimentation, decline in land productivity, accelerated land degradation, and flood. (Shrestha et al. 2006)

The direction of national strategy policy focuses on environmental development priorities and disaster management. This is related to BP-DAS Barito (2009), stating that there are critical land and very critical land of 761,042.60 ha in South Kalimantan Province. Moreover, there are about 76,635.10 ha of critical land in Watershed Batulicin or about 15% of Tanah Bumbu Regency area. The critical land in a watershed can cause abnormal fluctuations in the supply of water discharge for domestic and wetland-agricultural needs.

Floods often happened in Tanah Bumbu Regency including in Watershed Batulicin, there were 8 districts and 39 villages as the flooding points in the period from 2007 to 2010, while the land area with the criteria of fairly vulnerable, vulnerable and highly vulnerable to flooding was 250,151 ha or 50.6% of the total land area of Tanah Bumbu Regency (Balitbangda of South Kalimantan and Forestry Faculty of Lambung Mangkurat University, 2010). Those indicated that there were many flooding points and high levels of vulnerability to flooding in Watershed Batulicin; therefore, it was necessary to conduct study on watershed characteristics to restore the carrying capacity of Watershed Batulicin in South Kalimantan Province, capable to inflict positive impacts on the flood control and the reduction of disaster risk.

The purposes of this study were: 1) to find out the condition of watershed characteristics determining the carrying capacity of Watershed Batulicin, consisting of 7 sub-watersheds; 2) as the reference for the efforts to control flood vulnerability in Watershed Batulicin.

METHODS

The study required primary data from the field and secondary data from some related agencies, both government and private. The study was descriptive quantitative. The results of the study provided spatial descriptions about the levels of flood vulnerability and directives of watershed management to control the flood suppliers in Watershed Batulicin based on the environmental component parameters measured quantitatively. It used ecoregion approach of watershed while the process of analysis and presentation were carried out spatially using Geographic Information Systems technology, with the result that the study contained geographic references and was presented in the form of map.

The parameters observed or measured in this study were: a) land cover; b) rainfall; c) watershed morphology (watershed shape, river network pattern, and water discharge); and d) critical land. These characteristic parameters become the references in the efforts to restore the carrying capacity of Watershed Batulicin, in accordance with Faisol *et al*. (2009) suggesting that the time series data are used to find out the changes in the condition of characteristics of a watershed. Furthermore, Sirang *et al*. (2010), the preparation of a data

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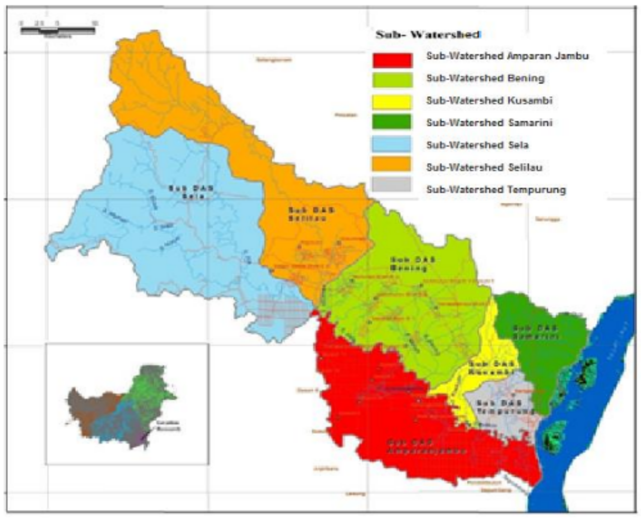
base of watershed characteristics is carried out in order to plan the watershed management and the forest and land rehabilitation.

RESULT AND DISCUSSION

Watershed and Sub-watershed

Geographically, Watershed Batulicin is located at 115^0 29' 49.65" – 116^0 3' 50.72" BT and 2^0 58' 29.39" – 3^0 29' 41.38" LS. The width of Watershed Batulicin is 142,783.37 ha divided into seven Sub-watersheds namely: 1) Sub-watershed Sela 40,540.7 ha (28.39 %); 2) Sub-watershed Selilau 30,943.3 ha (21.67 %); 3) Sub-watershed Bening 26,786.6 ha (18.76 %); 4) Sub-watershed Amparan Jambu 25,303.1 ha (17.72 %); 5) Sub-watershed Samarini 8,761.5 ha (6.14 %); 6) Sub-watershed Kusambi 5,336.35 ha (3.74); 7) and Sub-watershed Tempurung 5,111.9 ha (3.58 %).



Based on the characteristic condition of Watershed Batulicin consisting of 7 Sub-watersheds in 6 districts, and the number of the civilians, Watershed Batulicin became the government priority to handle (Ministry of forest 2009). The increasing human population can degrade the water quality and quantity (Kometa and Ebot, 2012).

Figure 1: Map of Sub-watershed Distribution

2. Land Use

Tabel 2. Land Cover of Watershed Batulicin

No	*Land Use*	*Width (ha)*	*(%)*	*No*	*Land Use*	*Width (ha)*	*(%)*
1	Secondary dryland forest	47,211.6	33.1	9	Shrub swamps	2,488.1	1.7
2	Shrubs	16,461.0	11.5	10	Dryland farming	33,706.6	23.6
3	Plantation	20,098.5	14.1	11	Dryland farming mixed with shrubs	4,400.3	3.1
4	Settlements	3,118.2	2.2	12	Rice field	60.4	0.1
5	Open ground	5,418.9	3.8	13	Embankment	1,698.0	1.2
6	Waterbody	190.4	0.1	14	Mine	5,227.3	3.7
7	Secondary mangrove forest	1,628.7	1.1	15	Swamp	309.9	0.2
8	Secondary swamp forest	765.4	0.5		*Total (Ha)*	*142,783.4*	*100*

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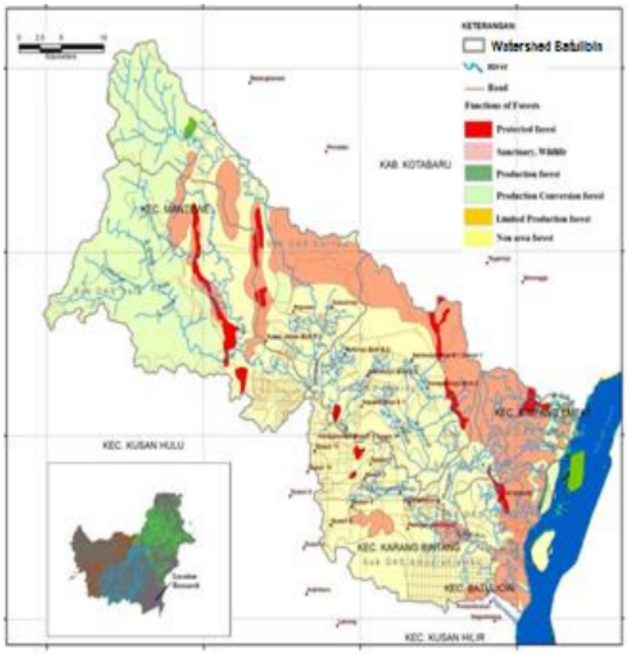

Figure 2. Map of Land Cover

The types of land cover in Watershed Batulicin were dominated by secondary dryland forest of 47,211.6 ha (33.1%), dryland agriculture of 33,706.6 ha (23.6%) and plantation of 20,098.5 ha (14.1%). The shrub vegetation generally was on the area so far from settlements that was not well utilized. The plantation activities in Watershed Batulicin were dominated by oil palm plantation and smallholder plantation of rubber. The land use in accordance with the designation will give the maximum profit, for the benefit of the water system and the social prosperity (Zhang and Wang, 2007).

Rainfall in Watershed Batulicin

According to the results of the rainfall records at Weather Station Karang Bintang in the period from 2002 - 2013, the average annual rainfall was 2,471.6 mm and the average monthly rainfall 205.9 mm. The highest average monthly rainfall occurred in January up to 263.8 mm as the result of the very high frequency of rainy days and rain volume in this month while the lowest monthly rainfall occurred in September up to 115.3 mm. The average annual rainy days in Watershed Batulicin were 226.9 days with the average monthly rainy days as much as 18.78 days. Sosrodarsono *et al*. (2003), the rainfall is needed as a reference to arrange the plan of flood control. Furthermore, Asdak (2010), rainfall plays an important role in hydrologic cycle.

Drainage

Watershed Morphology

Sub-watersheds Bening and Samarini had RC (*Ratio circularity*) value close to the value of 0.5 (rounded), so if there were flood discharge, the flood would occur quickly with high fluctuation. It happened because the concentration time of the rainwater flowing towards the

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outlet became shorter. In Sub-watersheds with RC values of 0.1 - 0.3 (elongated), the concentration time of rainwater flowing towards the outlet was longer with low fluctuation in the case of flood discharge. It could occur in Sub-watersheds Amparan Guava, kusambi, and Seliau.

Overall, the river drainage pattern in Watershed Batulincin was dendritic: medium, which indicated that the drainage system was formed lightly. The sub-watershed with dendritic drainage pattern: medium – subtle was only Sub-watershed Samarini, indicating that the sub-watershed had a good drainage system; however, this sub-watershed was likely to be experiencing drought in the dry season due to low infiltration rate.

Watershed Morphometry

The river density or drainage density is the comparison between the length of the entire river channel and the width of the land surface accommodating the river. According to Lynsley (1949), if the value of the drainage density is low/ less than 1 mile / mile2 (0.62 km / km2), the watershed will experience flooding whereas if the value of the drainage density is high or greater than 5 mile / mile2 (3.10 km / km2), the watershed will often experience drought. The drainage density of Watershed Batulicin is presented in Table 1.

Table 1. Drainage Density in Watershed Batulicin

No.	*Watershed / Sub-Watershed*	*Width (Km^2)*	*Length of River (Km)*	*Dd (Km/Km^2)*	*Density Level*
	Batulicin	1,427.83	948.888	0.665	Medium
1.	- Amparan Jambu	253.03	90.139	0.356	Low
2.	- Bening	267.87	173.205	0.647	Medium
3.	- Kusambi	53.36	61.52	1.153	Medium
4.	- Samarini	87.62	112.027	1.279	Medium
5.	- Sela	405.41	200.322	0.494	Low
6.	- Selilau	309.43	178.548	0.577	Low
7.	- Tempurung	51.12	43.035	0.842	Medium

The level of drainage density presented in Table 1 indicated that Sub-watershed Amparan Guava, Sela and Selilau would potentially experience frequent surface runoff and flooding whereas the other sub-watersheds such as Samarini and Kusambi would tend to experience drought at the peak of dry season. The sub-watersheds with the density conditions described above could be managed with the preventive measures by conducting soil conservation activities both in vegetative and mechanical ways (ponds, control dams, dams).

Ogden (2011), significant changes in peak discharge and runoff volume can be seen by increasing the density of river network. Kadir (2014), the watershed with high drainage density will have better hydrological condition compared to the one with low drainage density. The more drainage density going into the soil will increase the supply of underground water (Asdak, 2010 and Indarto, 2010).

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Water Discharge of Watershed

Department of Forestry (2009) stated that one of the criteria and indicators of watershed assessment is to account the river regime coefficient. The result of the study showed that the river regime coefficient of Watershed Batulicin was <50, considered good. However, the efforts to maintain the condition of the water discharge and to increase its function as the regulator of water system are still needed.

The average monthly water discharge in Watershed Batulicin during 1995 to 2004 was quite varied as the comparison of the average water discharge in May - September and October - April. The river regime coefficient or the comparison between the lowest and the highest monthly water discharges was 1:2 up to 1: 15, and it appeared that the increasing year made the ratio between the lowest and highest monthly water discharges become higher. Moreover, Balitbangda of South Kalimantan (2010) stated during 2007-2010 there were a number of floods in 8 districts and 39 villages in Tanah Bumbu including in Watershed Batulicin. The coefficient of river regime is a number showing the comparison between the value of maximum discharge (Qmax) and minimum drainage rate (Qmin) in a watershed/ sub-watershed. The measurement data of the average water discharge in May 2014 was 642,774 m3/s, while the lowest average water discharge during 1995 to 2004 was 29,612 m3/s with the river regime coefficient 1:21. Kadir *et al*. (2013), forest vegetation and natural rubber increase the infiltration capacity and normalize the water discharge fluctuation. Papa *et al*. (2008), the data of water discharge fluctuation can be used to estimate flood.

Critical Land

Based on the criteria of critical land determination, which take account the conditions of land cover/ land use, slope, erosion, rock and management, the critical level of land could be found out. The data of critical land level were obtained from updating reports of spatial data about critical land issued by the Management Agency of Watershed Barito year 2009; the land included in the very critical criterion in 2009 covered 3,809.6 ha (21.11%) and in 2014 8,257.44 ha (5.78%). It indicated that Watershed Batulicin needed to be restored through some efforts such as the rehabilitation of forest and land to increase the carrying capacity of the watershed as the water system regulator and the flood vulnerability control. The data of critical land levels in 2009 and 2014 are presented in Table 2.

Table 2. Level of Critical Land

No.	*Classification*	*Year 2009*		*Year 2014*	
		Width (Ha)	*Percentage (%)*	*Width (Ha)*	*Percentage (%)*
1.	Not Critical	379.7	0.27	423,59	0,30
2.	Potentially Critical	35,186.0	24.64	53.437.42	37,43
3.	Rather Critical	71,361.1	49.98	54.253,34	38,00
4.	Critical	32,047.0	22.44	26.411,58	18,50
5.	Very Critical	3,809.6	2.67	8.257,44	5,78
	Total	142,783.4	100.00	142,783.4	100.00

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Rueda (2010), the conservation of soil and water is an effort to reduce the rate of deforestation. Bukhari and Febryano (2008) reported that people can practice agroforestry system on critical land, the traditional agroforestry system managed in accordance with the local wisdom and condition. Saifillaili (2013) suggested that it is necessary to improve the rehabilitation of forest and land that have already been implemented to reduce the critical land. Arsyad (2010), the conservation of soil and water is an effort to reduce the critical level of land in watershed or sub-watershed.

CONCLUSIONS AND RECOMENDATIONS

1. Watershed Batulicin in South Kalimantan Province consists of 7 sub-watersheds and is administratively included in 6 districts.
2. The land covers in Watershed Batulicin were dominated by secondary dryland forest.
3. The coefficient of river regime in Watershed Batulicin was 1:21.
4. The critical level of critical land and very critical land covered 8,257.44 ha (5.78%).

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