16-Carrying Capacity of Satui

by Ichsan Ridwan

CARRYING CAPACITY OF SATUI WATERSHED IN SOUTH KALIMANTAN PROVINCE, INDONESIA

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ABSTRACT

Regional Research and Development Agency recorded that flood prone areas in Tanah Bumbu Regency including in Satui watershed from 2007 to 2010 increased to 22 villages (Badan Penelitian dan Pengembangan Daerah, 2010). Critical land in Satui watershed was 31% of the entire area (Balai Pengelolaan Daerah Aliran Sungai Barito, 2013). The number of farmers who need land resources to improve their welfare increases to 197,229 households every year. The characteristics assessment study and the efforts in establishing sustainable productive land conditions based on the carrying capacity of Satui watershed were carried out using an ecological approach in which the analysis process and presentation were done spatially. Characteristics of updating parameters of carrying capacity classification include: a) Land condition; b) Quality, quantity and continuity of water (water system); c) Socio-economic and institutional aspects; d) Water building investment; and e) Spatial use. The results of the assessment criteria and weighting indicated that 129.25 areas were classified into the areas with restored carrying capacity. The effort in restoring the carrying capacity improves the devices for environmental protection and management to increase environmental quality index, to control flood vulnerability, to manage water system, and to improve community welfare.

Keywords: Carrying capacity, Watershed

INTRODUCTION

Flood prone areas in Tanah Bumbu Regency including in Satui watershed from 2007 - 2010 increased to 22 villages (Badan Penelitian dan Pengembangan Daerah, 2010). Critical land in Satui watershed was 31% of the entire area (Balai Pengelolaan Daerah aliran sungai Barito, 2013).

Nan et al. (2005) stated that rainfall with a high intensity and lasted for long periods of time in the upstream and central watershed can cause flooding. Flood events can increase due to human activities in using land without sustainability (Kadir et al., 2013).

The number of farmers who need land resources to improve their welfare has increased every year to 197,229 households. The increase in human population and the change in land use on a watershed is a major problem because it can degrade the quality and quantity of water (Kometa & Ebot, 2012).

Kusuma (2007) stated that the component interaction in the watershed ecosystem can be expressed in the form of input and output balance and it characterizes the hydrological condition of the ecosystem. Furthermore, Rayes (2007) asserted that in utilizing natural resources in a watershed for certain land use, it is necessary to take thorough considerations

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before making decisions due to the high competition in land use, both for agriculture and non-agriculture.

Flood is a condition in which the river flow discharge is relatively larger than usual discharge due to the rain in the upstream or in a certain place occurring continuously, so the runoff cannot be accommodated by the riverbed and the water overflows and inundates the surrounding area (Nan et al., 2005).

The amount of flood water supply is identified from the amount of rainfall and the change in land cover (Paimin et al., 2009). Land cover is the main factor causing the variation of surface flows which is the source of flood vulnerability, despite the change in rainfall (Jiang et al., 2008).

The efforts of forest and land rehabilitation are focused on the watersheds experiencing increased degradation in forests and land so that their carrying capacity as water regulator (hydrological function), ecosystem balance and community welfare improvement can be restored.

The aim of the evaluation and improvement of Satui watershed carrying capacity is to find out the classification of Satui watershed carrying capacity and its improvement as an effort to control flood events. In addition, it is expected to provide benefits to ensure biophysical environmental sustainability and to improve socio-economic welfare of the community.

METODHOLOGY

Location and Object

The study was conducted in Satui watershed area of 62,558.56 ha which is geographically located at 30 44" 14.47" SL and 1140 37" 2.25" EL. Administratively it consists of 4 sub-districts and 44 villages, and ecologically it consists of 2 subwatersheds. The objects of the study include 1) Land condition; 2) Water system; 3) Socio-economic and institutional aspects; 4) Water building investment; and 5) Spatial use.

Materials and Equipment

Materials and equipment for this study include 1. Map; 2 HardWare; 3. SoftWare; 4. Currentmeter; 5. Water level; 6. Global Positioning System; 7. Stop watch; 8. Meter gauge; 9. Land drill; Ring; and 11. Camera.

Techniques of Data Collection

In order to find out the role of biophysical and socio-economic characteristics toward the carrying capacity of Satui watershed, the primary data from the field and secondary data from government and private institutions were taken.

This study is descriptive quantitative research and the results of the study provide a spatial description about the classification of carrying capacity and the management model which then become the reference for the policy making and the management of the watershed. The approach used in the study was the watershed ecological approach in which the process of analysis and presentation were carried out spatially by utilizing Geographic Information System technology.

Determination of Watershed Classification

The procedures of data analysis for this study were through weighting, class determination, score calculation and assessment of each sub classification criteria of the watershed. The determination of watershed classification was carried out based on the total assessment and weighting of the criteria/sub criteria ranging from 50 to 150. The determination of watershed classification was determined based on the total score of watershed qualification class as follows:

1. The total score < 100 indicates that the watershed carrying capacity is maintained.
2. The total score > 100 indicates that the watershed carrying capacity needs to be restored.

The classifications were based on the condition of land's carrying capacity which further became the reference for the policy making and management of watershed in order to obtain optimal results to ensure the balance of environment and water system, and to provide real socioeconomic benefits for the community, as presented in Attachment 1. The reference framework of Satui Watershed Carrying Capacity is presented in Figure 1.

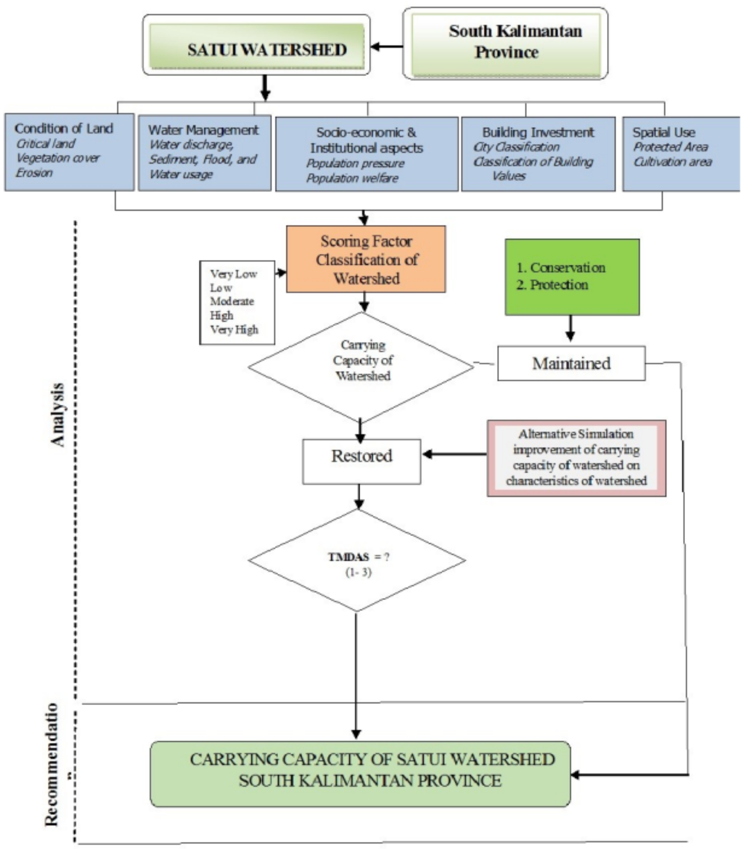

Figure 1. Reference Framework of Determination of Satui Watershed Carrying Capacity

RESULTS AND DISCUSSION

A. Characteristics of Satui Watershed Carrying Capacity

Critical Land

A study of land cover conducted in Satui watershed revealed the data about the condition of land cover including the vegetation as the main factor determining the level of land criticality. In addition, it also found out that there was a decrease in land criticality resulting

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from the simulation of efforts at enriching land cover vegetation, as presented in Figure 2 and Table 1.

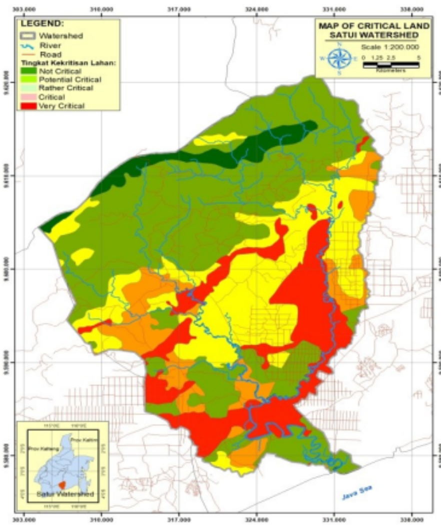

Figure 2. Critical Land in Satui Watershed

Table 1. Levels of Land Criticality

No.	Levels of Land Criticality	Area (ha)	Percentage (%)	Criteria of Restoration
1	Not Critical	13,435.19	16.56	High
2	Potential Critical	5,826.77	7.18	Low
3	Rather Critical	27,428.99	33.82	Very High
4	Critical	30,939.29	38.15	Very High
5	Very Critical	3,478.18	4.29	Very Low
	Total	**81,108.41**	**100.00**	**-**

Critical land is a land that is less functioning as water regulator, less good as a production medium to grow vegetation for land cover (Law No. 37 of 2014 on Soil and Water Conservation). Table 19 shows that there was a land with a criterion of high critical land area of 30,939.29 ha (38.15%) in Satui watershed, so according to the rule it can be categorized as very high restoration criteria where on the existing condition in the upper Satui watershed was found a number of coal mining activities, open land and shrubs. It is in line with Ruslan et al. (2013) and Kusuma (2007) suggesting that the interaction of land cover vegetation components within the watershed ecosystem can be expressed in terms of input and output equilibrium, characterizing the hydrological ecosystem. The very critical land in Satui watershed was because the vegetation components of the watershed ecosystem were less functioning to protect rainfall and control the surface runoff and erosion (Yu, 2003; Kadir, 2014).

1. Land Cover

Land suitability is used to test the accuracy of land cover data with the real condition in the field used as the confidence basis of data in a study. This study used the land cover data in

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2014. The result of land cover classification in Satui watershed is presented in Attachment 2.

Table of suitability consisted of 50 survey points scattered throughout Satui watershed area as the study area. The result of the suitability was 92%, which means that from 50 test points there were 4 mistakes because the points in the field was taken by a small coverage whereas in the classification it used a wide coverage. Hence, the information of the classification was gathered using a wide coverage and possibly was less precise when it was digitized with image map.

Based on data presented above, it can be found out that the process of land cover change in Satui watershed during 2000, 2003, 2006, 2009, 2011 and 2014 consisted of eleven predefined sample classifications.

The percentage of vegetation cover in Satui watershed was 40.29% of the land cover. Based on the Percentage of Vegetation Cover, it can be said that the percentage of land cover is categorized into moderate restoration qualification.

2. Erosion

The results of rainfall analysis, soil physical properties and slope were processed using equations in the USLE model. Recapitulation of the estimation of erosion on various land units and land covers, and the results of erosion calculation are presented in Table 2.

Arsyad (2010) stated that erosion is an event of moving or transporting soil or parts of the soil from one place to another by natural media in a watershed. Furthermore, Yu (2003) asserted that the low infiltration capacity causes the great amount of erosion as a result of high surface runoff. The condition of erosion is one of the factors of biophysical characteristics assessment of watershed in order to determine the classification of its restoration.

Table 2. The amount of erosion on each land unit in Satui watershed

No	Land Unit	Land Cover	(R)	(K)	LS	(C)	(P)	PE	Solum of Soil	T	EI
1	UL1	PLK	2,132.67	0.139	0.980	0.60	1	106.24	> 90	60	1.77
2	UL2	SB	2,132.67	0.504	0.441	0.25	1	72.25	60 - 90	15	4.82
3	UL3	PK	2,132.67	0.174	0.123	0.30	1	8.37	60 - 90	15	0.56
4	UL4	PLK	2,132.67	0.184	0.551	0.60	1	79.30	> 90	60	1.32
5	UL5	PK	2,132.67	0.166	0.137	0.20	1	5.91	60 - 90	15	0.39
6	UL6	T	2,132.67	0.109	0.252	0.95	1	33.91	30 - 60	12	2.83
7	UL7	PK	2,132.67	0.042	0.571	0.20	1	6.20	60 - 90	15	0.41
8	UL8	SB	2,132.67	0.250	0.404	0.25	1	32.88	30 - 60	12	2.74
9	UL9	HS	2,132.67	0.157	0.362	0.10	1	7.40	60 - 90	15	0.49
10	UL10	T	2,132.67	0.060	0.269	0.95	1	19.95	60 - 90	15	1.33
11	UL11	PLK	2,132.67	0.337	0.111	0.60	1	29.14	60 - 90	15	1.94
12	UL12	T	2,132.67	0.144	0.285	0.95	1	50.70	60 - 90	15	3.38
13	UL13	SB	2,132.67	0.164	0.084	0.25	1	4.48	30 - 60	12	0.37
14	UL14	T	2,132.67	0.149	1.945	0.95	1	359.32	> 90	60	5.99
15	UL15	**SB**	2,132.67	0.219	0.466	0.25	1	33.27	60 - 90	15	2.22
					Average						2.04

Source: Result of primary data in 2016

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Notes:	IE = Index of erosion in watershed	PEi = Predicted erosion on land unit i (ton/ha/year)
	IEi = Index of erosion in land unit i	A = Area of watershed (ha); Ai = Area of land unit i
	T = Erosion allowed in watershed	Ti = Erosion allowed in land unit i
	PLK = Dryland farming	SB = Shrubs
	PK = Plantation	T = Open land
	HS = Secondary Forest	

The average Erosion Index of Satui watershed was 2.04, so it was included in **very high** restoration classification. Kadir (2017) stated that based on the amount of erosion and erosion hazard level in Tabunio watershed, the highest amount of erosion was 219.08 ton/ha/yr. It becomes the reference for the determination of forest and land rehabilitation model having an implication to decrease the erosion hazard level and erosion index.

4. Water System

Water quality criteria were selected to describe the hydrological conditions of the watershed. The criteria of quality, quantity and continuity of water (water system) were selected to describe the hydrological conditions of Satui watershed, approached with five sub criteria: a) flow regime coefficient ; b) annual flow coefficient; c) sediment load; d) flood and; e) index of water use.

a. *Flow Regime Coefficient (KRA)*

The assessment of flow regime coefficient was carried out in Satui watershed, Tanah Bumbu Regency from 2016 to 2017. The measurement of daily river water discharge was the basic data of the flow regime coefficient assessment. The results of the water discharge measurement are presented in Tables 24 and 25. Data of water discharge consist of: 1) Total daily water discharge; 2) Average monthly water discharge; 3) Maximum monthly water discharge; and 4) Minimum monthly water discharge. Flow regime coefficient (KRA) was analyzed through the results of the water flow measurement from 2007 to 2017 in the downstream watershed.

The result of analysis showed that KRA was 17.29, so it is stated that Satui watershed was included in the high restoration qualification. Watersheds can be viewed as natural systems that place biophysical hydrological processes as well as complex socio-economic and cultural activities. It cannot be separated from increasing demands on natural resources (water, land and forests) due to the increasing population growth which leads to changes in watershed conditions.

The identification of various biophysical components of the KRA is the key in the watershed monitoring and evaluation (M & E) program, in the effort to collect data and information needed for evaluation purposes in order to ensure the achievement of watershed management goals and objectives. The collection of KRA data and information should be done periodically, by utilizing the development of existing instrumentation, information, and communication technology, for example by automatic data.

According to Zhang et al. (2008), watersheds are generally considered as development units, especially for regions that rely on water availability, so KRA is one of the information for water supply. Furthermore, Hernandez-Ramirez (2008) suggested that the planning for land use, and the management and restoration of ecology have used watershed as a management unit for water supply.

b. *Annual Flow Coefficient*

The monitoring and evaluation of annual flow coefficient are intended to determine the development of quantity, quality and continuity of water flows from Satui watershed after the

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exploitation, exploitation and / or changes in land use of natural resources. The analysis of determination of the annual flow coefficient is through the following equation, while the criteria for the annual flow coefficient assessment are as follows.

The results of the assessment analysis of annual flow coefficient showed that the C value was 0.56, so it can be stated that Satui watershed was included in **very high restoration** qualification. Watershed monitoring and evaluation for annual flow coefficient (C) is intended to obtain a comprehensive picture of watershed development, which is emphasized on land use, water system, socio-economic and institutional aspects.

Kometa & Ebot (2012), revealed that the main problems facing watershed ecosystems are generally the increase in human population and the change in land use, which can degrade the quality and quantity of water. Furthermore, according to Kusuma (2007), the interaction of water system including the components of annual flow coefficient in the watershed ecosystem can be expressed in the form of input and output equilibrium. This characterizes the hydrological condition of the ecosystem in the context of its restoration effort.

c. ***Sediment Load***

Sediment load was measured at the same place as the water discharge was measured and was to reflect the condition of the downstream area of Satui watershed. The results of the Sediment Load (MS) assessment showed that the value of sediment load was 14.4 tons / year, so it can be said that Satui watershed was included in medium restoration qualification that caused a change in agricultural practices. Kadir at al. (2013) stated that the land use for rubber trees may contribute to watershed restoration. It is because rubber trees increase infiltration capacity, and reduce surface run-off, erosion and sedimentation.

Roig-Munar at al. (2012) suggested that land degradation causing erosion and sedimentation can affect changes in river conditions. Furthermore, Lantican, Guerra, & Bhuiyan (2003) suggested that the impacts of erosion and sedimentation include a) the increasing trend of canal dredging consequent; b) the significant decrease in productivity and incomes of farmers; c) the increasing cost of routine operation and maintenance of the river.

d. Flood

Flood is an event that occurs when excessive water flow inundates the land. Flooding in this case is defined as overflowing river water that inundates certain areas (usually dry areas) that significantly causes harm both material and non-material to humans and environment.

Data of flood frequency were obtained from the reports of flood incidents or direct observation. Flood events in the downstream of Satui watershed were more than once a year so Satui watershed was included in very high restoration qualification. Kadir (2014) stated that the flood events can occur due to human activities in utilizing the land that are not based on the principles of sustainability and the result of prolonged rain on the upstream of watershed. Forest exploitation and other land uses that are not based on environmental sustainability may also cause flooding.

According to Munaf (2007), the tendency of the absence of coordination and synergy of watershed management in the upstream and downstream, among administrative areas and among sectors is one of the factors causing environmental damage, therefore the concept of integrated watershed need to be realized (one river, one plan and one integrated management). According to Kim & Choi (2011), floods have the potential to cause hazards and threats to the environment, human life, and infrastructure, so there is a need to restore Satui watershed to control flood vulnerability.

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e. *Water Use Index*

Water availability is one of the decisive factors for success in agricultural cultivation. Almost all regions with the irrigated agriculture are the largest water users. The determination of Water Use Index of Satui watershed in Tanah Bumbu Regency was through a regression.

Based on Table 3 of the assessment criteria of water use index, it is seen that the water use index was 1.28 m^3/s so it is stated that Satui watershed was included into very high restoration qualification. Paimin et al. (2010) asserted that the potential of flood vulnerability is a set of conditions that determine whether natural parameters, including water use index and management potentially cause flood in the watershed. Flood occurs in the middle and downstream of the watershed, while the upstream is the supplier of flood water, and thus the rehabilitation of forests and land in the upstream needs to be prioritized as an effort to restore the watershed.

Soemarno (2008) suggested that the success of the watershed restoration in the upstream of watershed is determined by a) water resources; b) soil resources; c) technological elements; e) the surrounding regional economy; and d) human resources as the main actors.

Kadir at al. (2016) stated that the increasing need for water use can cause imbalance with the availability of water, so in turn it has an impact on the environmental damage. Furthermore, it is stated that the direction of watershed restoration is through the enrichment of vegetation types based on the ability and suitability of land and the function of area, and conservation through civil engineering to increase the watershed carrying capacity.

Socio-Economic and Institutional Aspects

The socio-economic and institutional criteria consist of a) population pressure on land; b) population welfare level; and c) existence and enforcement of social rules about natural resources conservation.

a. *Population Pressure on Land*

Based on the assessment criteria of Land Availability Index (IKL), it is seen that the Land Availability Index (IKL) with a value of 0.1803 has the score of 1.50. It is stated that Satui watershed was included into the very high restoration qualification. According to Kadir (2014), the land damage occurs due to human activities in land use that are not based on sustainability principles. Forest exploitation and other land uses that are not based on environmental sustainability can damage the land availability index.

Population condition is very influential on the availability of land in an area, especially the availability of land for facilities and infrastructure (settlement) as well as for agriculture. Human beings require land to be allocated for physical facilities and infrastructure in their activities and as a source of food production. These two needs for land often clash one another when the fulfillment of one land need is more dominant than the other need. Conflict of interest in managing the land can cause population pressure on land. Population pressure on agricultural land that exceeds the ability of land can lead to a decline in the ability of land for agriculture. This can lead to degradation of agricultural land if it happens continuously.

One of the factors causing the destruction of biodiversity is human activities, such as indiscriminate logging or excessive use. It is because the community's knowledge of biodiversity is still very low. The utilization of biodiversity for the community should be done sustainably, i.e. the benefits not only for the present generation but also for future generation. In the utilization of biodiversity it is necessary to use the principles of responsibility, sustainability and benefits.

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b. *Population Welfare Level*

The poverty line is set using data from BPS (Statistics Center), equivalent to 320 - 400 kg rice/capita/year. Based on the number of poor families, it is apparent that the calculation of the Population Welfare Level was 6%, so it is stated that Satui watershed was included into moderate restoration qualification, which means that most people had high income. It can be seen from the activities of the people who used the land maximally regardless of the damage they caused from their activities such as gold mining in the river, logging and illegal mining.

If the parameter used is the average income per capita per year. From the results of data analysis for regency the average income per capita per year was 4,080,000 including the score of 0.75 with the low restoration qualification, indicating that people's income in Satui watershed was quite high.

c. Existence and Enforcement of Social Rules about Natural Resources Conservation

Data were obtained from community leaders and reports from relevant agencies. The data for the analysis were about the existence of norms related to conservation and water and its implementation in the watershed area.

The data were closely related to the earlier discussion about the community's pretty high income, where the community was very dependent on natural surroundings. There were some rules or norms that previously should not have been violated by the community. After direct observation in the field and interview with the community it was found out that the existence and enforcement of rules/norms was in the qualification of moderate restoration, with a score of 1, indicating that in addition to the norms in the community, the regulations and legislations should be enforced to keep the environment sustainable.

This fact shows that the wealth of natural resources and biodiversity is seen as a resource that can be extracted to get a surplus. On the other hand, the success of the acquisition of foreign exchange must be paid with damaged local ecosystem and result in disruption of global ecosystem. Furthermore, in socio-culture there is a conflict of interest between the local cultural orders and the modern culture inherent in the industrialization of exploited natural resources.

The issue, namely modernization, sees that local cultural orders are obstacles that must be "eliminated" or "replaced" so that the development process does not get seriously disturbed by local communities, while local people view industrialization from exploited natural resources as a threat to their customary rights to their environment. These incidents, especially on forest resources, are worsened by the number of illegal entrepreneurs who are only concerned with profit without considering the environmental damage they have created, which is a form of greed.

Water Building Investment

Values of the assets and investment of water buildings in a watershed reflect the size of man-made resources that need to be protected from environmental dangers of watersheds such as floods, landslides, sedimentation and drought. The greater the values of investment in a watershed are, the more important the handling of conservation and rehabilitation of forest and land in the watershed is. In other words, the scale of the watershed restoration becomes very high if the investment is very high and its biophysical condition has been degraded. Therefore, it can use the approach with sub criteria of city existence and water building investment values, such as reservoir/dam/irrigation channel.

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a. City Classification

The required data are the existence of city in the watershed and the category of the city. The information on the existence of the city is obtained from the map and/or observation. If in one watershed there is more than one city class, the highest class of city is used. The assessment criteria of city existence are seen in Attachmente 1.

The city in Satui watershed in the area of Tanah Bumbu regency is small city because it is located on the outskirt of Tanah Bumbu, so the score is 0.75, which is included in the qualification of low restoration. It means the influence of this area on the regency city is very small. Although the restoration classification is low, this area has to be considered because it affects the whole area of Satui watershed.

b. Classification of Water Building Value (IBA)

The data that need to be inventoried are the amount of the investment value of water buildings (reservoirs, dams, irrigation channels), which were in low restoration qualification. The estimated value of water building investment was about 15 < IBA < 30 billion rupiah.

Spatial Use

Forest areas are designated and/or established by the government to be maintained as permanent forests. Forest area that already has permanent legal force remains a "specific area" set by the government to maintain its existence as a permanent forest. Forest areas in Satui watershed have different functions. Each forest area has different conditions according to its physical condition, topography, flora and fauna as well as its biodiversity and ecosystem, so each forest area has a primary function.

a. Protected area

Satui watershed is dominated by non-forest area of 51,103.71 ha or 81.69%, while protected forest was 6,496.21 ha or 10.38%. Based on the percentage of protected forest area, it can be stated that Satui watershed was included into very high restoration criteria.

Protected forests have the primary objective to improve population welfare, and to raise public awareness to maintain and improve the function of protected forests for present and future generations, with the creation of a sustainable water system.

Changes in land use in protected forests result in significant changes in the hydrological condition of river system, which in turn have a potential to cause high flood risk in urban areas; therefore, rational policies of land use must be implemented to provide maximum benefits and minimize the loss as the impact of flood events (Zhang & Wang, 2007). Status and Function of Forest Area in Satui Watershed are presented in Table 3, while the Map of Area Functions and the Slope Map are presented in Figures 3 and 4.

Table 3. Status and Function of Forest Area in Satui Watershed

No	Status and Function of Forest Area	Area	
		Ha	%
1	Protected Forest	6,496.21	10.38
2	Production Forest	733.16	1.17
3	Conversion Production Forest	1,166.64	1.86
4	Limited Production Forest	6.43	0.01
5	Non Forest Area (APL)	51,103.71	81.69
6	Nature Reserve, Nature Preservation Area	3,052.42	4.88
	Total	62,558.56	100.00

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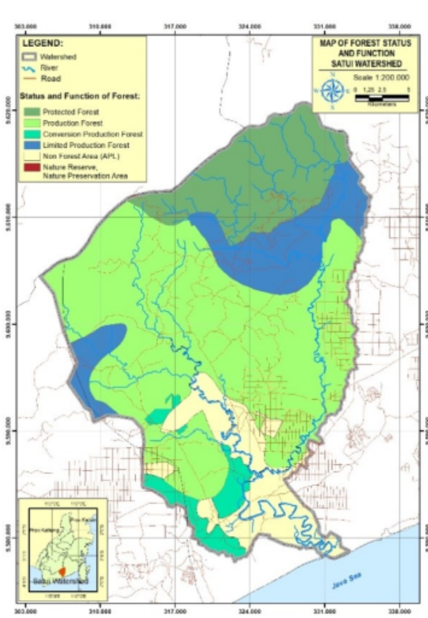

Figure 3. Map of Area Functions Figure

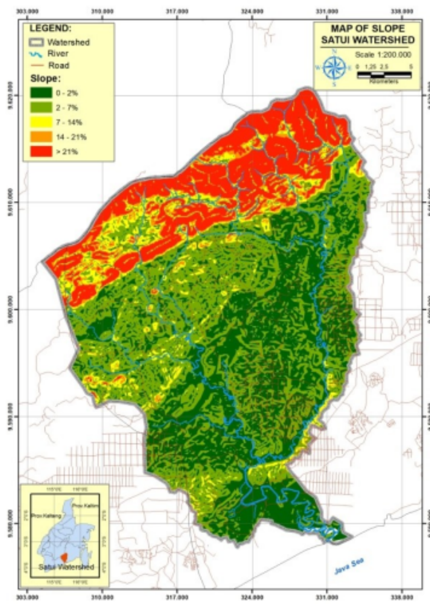

Figure 4. Map of Slope

b. *Cultivation area*

Cultivation area is a designated area with a primary function to be cultivated on the basis of conditions and potential of natural resources, human resources, and artificial resources to fulfill human needs.

Determination of watershed restoration classification criteria in cultivation area was based on slope percentage. Saud (2007) suggested that the higher the slope of land is, the higher the water is passed. The results of slope analysis using GIS in Satui watershed are presented in Table 4.

Table 4. Slopes in Satui Watershed

No.	Slopes	Area (ha)	Prosentase (%)
1	0 - 2%	27,428.99	33.82
2	2 - 7%	30,939.29	38.15
3	7 - 14%	5,826.77	7.18
4	14 - 21%	3,478.18	4.29
5	> 21%	13,435.19	16.56
	Total	81,108.41	100.00

Based on Table 6 it can be inferred that Satui watershed was dominated by 0 - 21% slopes of 64,195.05 ha or 79.15% of the Satui watershed area, so it was classified into very low restoration. It also reveals that in Satui watershed there are many areas with the opportunity for cultivation activities.

Baja (2012) stated that slopes are biophysical parameters of landform in a watershed which become the reference in the determination of land use for cultivation. In addition to vegetative measures, the rehabilitation for slightly hilly landform can be done by combining vegetative measures with civil engineering methods, which is one of the best alternatives (Kadir, 2014).

Ali et al. (2011) stated that human actions that alter the land use have increased the erosion rate. The area with higher rate of erosion is the area with relatively steep slopes when compared to other land covers. Such erosion is mostly affected by land cover and soil physical properties; for example, open land and shrubs are usually easy to get burnt, so the physical properties of the soil become damaged, and because in the rain most rain strokes directly on the soil surface, it results in high erodibility, and the erosion will be horrible too. Lopez et al. (2011) conducting an experiment of vegetation restoration scenarios found out that the erosion reduced to 16%. Kartasapoetra & Sutedjo (1991) also suggested that the main factors affecting erosion are soil physical properties and soil management. The soil that contains a lot of dust is the soil that is easily eroded. Control of runoff and erosion can be done by reforestation or by letting weeds and trees grow wild (Wang et al., 2006).

The result of soil depth analysis indicated that it was dominated by moderate soil depth (60-90 cm) and deep soil depth (> 90 cm). Rayes (2006) stated that the effective soil depth is the soil depth which is good for the growth of plant roots, i.e. until the layer that cannot be penetrated by plant roots. Hirzel & Matus (2013) found that the effective depth of soil is 20 cm and it greatly affects the productivity of plants in addition to climatic factors and soil chemical properties.

Slope is one of the variables used to study erosion. Badan Penelitian dan Pengembangan Daerah Provinsi Kalimantan Selatan dan Fakultas Kehutanan Unlam (2010) stated that in the anticipation of flood and its management, slope parameter is used. Paimin et al. (2009) suggested that slope is one of the parameters determining flood vulnerability.

The slope level in Satui watershed was dominated by the slope level of 0-2% in 27,428.99 ha or 33.82%, and the slope of 2-7% in 30,939.29 ha or 38.15%. The lowest is the slope of 14-21%, i.e. in an area of 3,478.18 or only 4.29%, which can slow the surface runoff. In addition, it allows a wider area for agriculture and plantation activities, by considering the capacity class and land suitability.

The conditions of topography that can affect erosion and sedimentation are the slope steepness and the slope length which are two factors determining the topographic characteristics of a watershed. On steep slopes, the potential for land degradation is particularly significant with respect to the high rate of surface run-off, causing high soil surface erosion and low chance for water to flow entering the soil (infiltration). Slope steepness, slope length and slope form can affect the extent of erosion and surface run-off (Rayes, 2007).

The determination of Satui watershed classification through weighting, class determination, score calculation, and assessment of each sub-criterion is presented in Table 5. The determination of watershed classification was based on the assessment and weighting of the criteria / sub-criteria, resulting in the total value of 129.25. Therefore, based on the total score (> 100) in Table 5, Satui watershed was classified into the watershed with restorable carrying capacity.

The restoration of Satui watershed carrying capacity for biophysical-environmental, economic and social aspects includes 1) clean water supply; 2) food supply; 3) genetic resource supply: 4) biodiversity supply; 5) shelter and living space; and 6) recreation and ecotourism.

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The effort to restore the carrying capacity of Satui watershed in Tanah Bumbu Regency is a positive step in improving the conservation and management of the environment which is continuously developed by the Ministry of Environment and Forestry, in order to improve the environmental quality index (IKLH), to control flood vulnerability, and to improve community's welfare.

B. Determination of Watershed Classification Criteria

Table 5. Value of Assessment Criteria of Satui Watershed, Tanah Bumbu Regency

Criteria/sub criteria	Weight	Criteria of Assessment			Value (weight x score)
		Class	Restoration Qualification	Score	
A. Land (40)					
1. Percentage of Critical Land	20	PLLK > 20	Very High	1.50	30
2. Percentage of Vegetation Cover	10	20 <PPV≤ 40	Moderate	1.00	10
3. Index of Erosion /IE	10	IE > 2	Very High	1.50	15
B. Water System (20)					
1. Flow Regime Coefficient /KRA	5	15 < KRA ≤ 20	High	1.25	6.25
2. Flow Coeffisient /C	5	C > 0.5	Very High	1.50	7.5
3. Sediment Load (MS)	4	15 < MS ≤ 20	Moderate	1.00	4
4. Flood	2	> 1 x/year	Very High	1.50	3
5. Water use index (IPA)	4	IPA > 1.00	Very High	1.50	6
C. Socio-economic & Institutional Aspects (20)					0
1. Population pressure on land expressed with index of farming land availability	10	0<IKL≤ 0.5	Very High	1.50	15
2. Population Welfare Level	17	10< TKP ≤ 20	Moderate	0.75	12.75
3. Existence and enforcement of social rules pro conservation of watershed	3	Class 2	Moderate	0.75	2.25
D. Investment of Water Building (10)					0
1. Classification of City	5	Small City	Low	0.75	3.75
2. Classification of Water Building Value	5	Rp 15 M<IBA≤Rp.30 M	Low	0.75	3.75
E. Spatial Use (10)					0
1. Protected Area	5	PTH ≤15%	Very High	1.50	7.5
2. Cultivation Area	5	LKB >70 %	Very Low	0.50	2.5
					129.25

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CONCLUSION

1. Satui watershed classification:

   a. Land conditions consisting of 1) the percentage of critical land included into very high restoration qualification; 2) the percentage of vegetation cover included into moderate restoration qualification; and 3) the erosion index included into high restoration qualification.

   b. Water system consisting of 1) flow regime coefficient with high restoration qualification of; 2) annual flow coefficient with very high restoration qualification; 3) sediment load with moderate restoration qualification; 4) flood with very high restoration qualification; and 5) water use index with very high restoration qualification.

   c. Socio-economy consisting of 1) population pressure with very high restoration qualification; 2) population welfare level with moderate restoration qualification; and 3) the existence and enforcement of social rules with moderate restoration qualification.

   d. Building water investment consisting of 1) city classification with low restoration qualification; 2) classification of water building values with low restoration qualification.

   e. Spatial use consisting of 1) protected area with very high restoration qualification; and 2) cultivation area with low restoration qualification.

2. Assessment criteria and weighting of Satui watershed was 129.25, so Satui watershed was classified into the watershed with restorable carrying capacity.

SUGGESTIONS

In order to conserve the environment in Satui watershed, it is necessary to restore the carrying capacity of Satui watershed in Tanah Bumbu Regency. It is a positive step in completing the devices for the protection and management of the environment in order to improve the environmental quality index, to control the flood vulnerability, to manage the water system and to improve the community welfare. Restoration of the carrying capacity of Satui watershed should be carried out through soil and water conservation through vegetative measures and civil engineering methods.

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APPENDIX - A

Attachment 1. Value of Assessment Criteria of Satui Watershed, Tanah Bumbu Regency

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		Class	Restoration Qualification	Score	
A. Land (40)					
1. Percentage of Critical Land	20	PLLK > 20	Very High	1.50	30
2. Percentage of Vegetation Cover	10	20 <PPV≤ 40	Moderate	1.00	10
3. Index of Erosion /IE	10	IE > 2	Very High	1.50	15
B. Water System (20)					
1. Flow Regime Coefficient /KRA	5	15 < KRA ≤ 20	High	1.25	6.25
2. Flow Coeffisient /C	5	C > 0.5	Very High	1.50	7.5
3. Sediment Load (MS)	4	15 < MS ≤ 20	Moderate	1.00	4
4. Flood	2	> 1 x/year	Very High	1.50	3
5. Water use index (IPA)	4	IPA > 1.00	Very High	1.50	6
C. Socio-economic & Institutional Aspects (20)					0
1. Population pressure on land expressed with index of farming land availability	10	0<IKL≤ 0.5	Very High	1.50	15
2. Population Welfare Level	17	10< TKP ≤ 20	Moderate	0.75	12.75
3. Existence and enforcement of social rules pro conservation of watershed	3	Class 2	Moderate	0.75	2.25
D. Investment of Water Building (10)					0
1. Classification of City	5	Small City	Low	0.75	3.75
2. Classification of Water Building Value	5	Rp 15 M<IBA≤Rp.30 M	Low	0.75	3.75
E. Spatial Use (10)					0
1. Protected Area	5	PTH ≤15%	Very High	1.50	7.5
2. Cultivation Area	5	LKB >70 %	Very Low	0.50	2.5
					129.25

Attachment 2. Suitability of Land Cover

No	Land Cover 2014	Result from the Field	Note
1	Dryland farming	Settlement	Not suitable
2	Dryland farming	Dryland farming	Suitable
3	Dryland farming	Dryland farming	Suitable
4	Open land	Open land/mining	Suitable
5	Open land	Open land/mining	Suitable
6	Open land	Open land/mining	Suitable
7	Dryland farming	Dryland farming	Suitable
8	Plantation	Plantation	Suitable
9	Plantation	Plantation	Suitable
10	Plantation	Plantation	Suitable
11	Open land	Open land/tambang	Suitable
12	Open land	Open land	Suitable
13	Open land	Open land	Suitable
14	Settlement	Settlement	Suitable
15	Settlement	Settlement	Suitable
16	Open land	Open land	Suitable
17	Open land	Open land	Suitable
18	Dryland farming	Dryland farming	Suitable
19	Dryland farming	Dryland farming	Suitable
20	Dryland farming	Dryland farming	Suitable
21	Open land	Open land	Suitable
22	Dryland farming	Dryland farming	Suitable
23	Forest	Forest	Suitable
24	Plantation	Plantation	Suitable
25	Open land	Open land	Suitable
26	Dryland farming	Dryland farming	Suitable
27	Open land	Open land/tambang	Suitable
28	Plantation	Plantation	Suitable
29	Dryland farming	Dryland farming	Suitable
30	Forest tanaman	Forest tanaman	Suitable
31	Open land	Open land	Suitable
32	Plantation	Plantation	Suitable
33	Open land	Open land	Suitable
34	Open land	Open land	Suitable
35	Shrubs	Shrubs	Suitable
36	Open land	Open land	Suitable
37	Plantation	Plantation	Suitable
38	Open land	Open land	Suitable
39	Open land	Open land	Suitable
40	Plantation	Plantation	Suitable
41	Settlement	Settlement	Suitable
42	Open land	Open land	Suitable
43	Shrubs	Shrubs	Suitable
44	Open land	Open land	Suitable
45	Shrubs	Shrubs	Suitable
46	Dryland farming	Settlement	Not Suitable
47	Open land	Tambak	Not Suitable
48	Dryland farming	Settlement	Not Suitable
49	Open land	Open land	Suitable
50	Dryland farming	Dryland farming	Suitable

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16-Carrying Capacity of Satui

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