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RESEARCH PAPER

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Exploring land cover changes in Satui Watershed of South Kalimantan through geographic information system (GIS)

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Abstract

Limited land resources affect the land conversion that causes the change in land cover conditions, caused by the need for land, which is inversely proportional to the availability of land. Land cover in the Satui basin in South Kalimantan province of Indonesia changed rapidly. Community activities on the land have caused changes in the land cover that have negative impacts on the sustainability of forest resources. Remote sensing and GIS are used to monitor and evaluate land cover changes that occur in the Satui basin. Therefore, it is necessary to monitor the suitability of land cover change to address the negative impacts caused by land cover change, so that the carrying capacity of the land can be maintained as well as ascertaining the extent of the land change since 2000 to 2014. The result of the land cover suitability analysis in Satui watershed from spatial data of land cover according to the GIS interpretation indicates 92% of the land as compliant with the land cover suitability standard and 8% as non-compliant. Changes in land cover that occurred during the years 2000, 2003, 2006, 2009, 2011 and 2014 in the Satui basin in general include changes in land function; over each period the land was affected by a decline in forest cover as they were being turned into commercial plantations, and more land was opened for various human activity.

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Introduction

Population growth has an effect on the increasing need and the use of space for human activities, one of which is the need for land (Wikantika, *et al.*, 2005). Changes in land use and land cover is mainly influenced by human activity (Fu *et al.* 2006; Luo *et al.*, 2008). The land-use change process is very important for land use planning, resource utilization and environmental management (Vela'zquez *et al.*, 2003; Gutman *et al.*, 2004; Turner *et al.*, 2004; Luo *et al.*, 2008). Changes in land cover surrounding watersheds is inevitable if there is population growth in that vicinity (Wangsadipoerra, *et al.*, 2008). Land cover is a variant in large areas because the process of land cover change occurs over a long period of time. Land cover conditions in an area has a variety of different land conditions, in addition there are always effects to the ecosystem as well as human life, directly or indirectly (Steel, 2012).

According to Koomen *et al.* (2007). land cover refers to vegetation and artificial constructions that cover the land surface. Land cover is related to the type of appearance on the surface of the earth such as buildings, lakes, vegetation, whereas land use is any type of use land by humans, ranging from agriculture, sports fields, residential housing, restaurants, and hospitals to cemeteries. The land cover in this study illustrates the vegetation and artificial constructions that cover the surface of the land (Burley in Lo, 1996). The construction is entirely visible directly from the remote sensing image. Three classes of data generally included in land cover are physical structures built by humans, biotic phenomena such as natural vegetation, crops and animal life, and the type of natural land formations.

Land use change is a complex, interrelated dynamic process between the natural environment and humans that have a direct impact on soil, water, atmosphere and other global environmental issues (Koomen *et al.*, 2007). Large-scale deforestation in the tropics transforming the land to agricultural land is one example of land use change that has a major impact on biodiversity, land, degradation and the

ability of the earth to support human needs (Lambin *et al.*, 2003). This study seeks to explore the changes in land cover based on Geographic Information System (GIS) interpretations and ground field checks 2000-2014.

Research methods

This study takes in a descriptive research type using spatial data of land cover, of the Satui Basin and GIS. The population and sample of this study are described in the following description: Population is a set of individuals or objects that can be known or measured clearly by the number limit (Tika, 2005). In this study the population is the area of Satui basin.

Samples are some of the objects or individuals representing the population (Tika, 2005). So the sample is determined based on the classification system that represents the population, this study explores 11 land cover classifications as in Table 1.

Source

The National Standardization Agency of Indonesia

The land cover classification in the table is modified based on twenty-three calculations of the Indonesian land cover classifications as per the Directorate General of Planning and Environmental Planning.

land cover compliance

This method is obtained from field surveys using the table of conformity. Sampling in this study is an area (area sampling) because the population is a watershed with a large area and has a heterogeneous morphological conditions, the tool used for sampling is the land cover survey of 2014. Method used in this study is the Simple Random Sampling technique because of the large watershed location and it is not possible to take a systematic point sampling method.

$$\text{Truth Interpretation Level} = \frac{\epsilon \text{ correct survey point}}{\epsilon \text{ points surveyed}}$$

The value of conformity can be determined using the above formula, i.e. by comparing the number of correct survey points with the total number of points of the survey (Mufarika, 2008).

Research Variables

This study utilizes spatial data of multi-temporal land cover which means the same area at different times. Variables in this research are: Land cover of the Satui watershed in 2000, 2003, 2006, 2009, 2011 and 2014

Research Stages

In detecting land cover changes in the watershed can use overlay techniques of land cover data with

watershed boundaries through Geographic Information Systems (GIS). Through Geographic Information System (GIS) is expected to analyze land cover change in Satui watershed obtained maximum results, know the trend of regional development and provide a picture of physical and social conditions in the study area based on the conditions and patterns of land cover development.

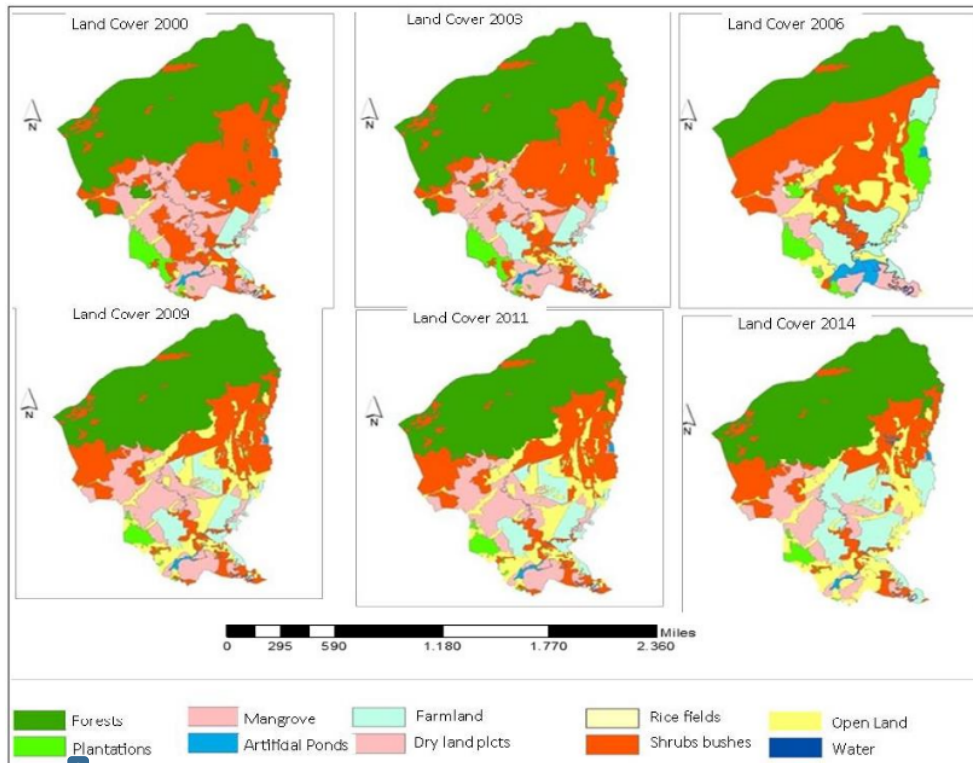


Fig. 1. Land Cover Change for the period of 2000 – 2014.

The land cover data used in this research is the land cover data recordings of the years 2000, 2003, 2006, 2009, 2011 and 2014; quality data that can be used as reference in the field of education and work. The land cover data is sourced from the Directorate General of Planology and Environmental Administration. The study followed 5 stages of data processing using the land using the GIS.

The first step was to source for the South Kalimantan Watershed Map originating from the Ministry of Forestry, Directorate General of Planology and Environmental Administration of the Satui basin. The second stage was the collection and processing of land cover data for the years 2000, 2003, 2006, 2009, 2011 and 2014.

The third stage was conducting a field check as the suitability of land cover with the classification of 2014.

The fourth stage was the process of making a land cover map of Satui watershed using the GIS to compute the required information of the area according to the earlier mentioned classifications. Fifth Stage was conducting an analysis of changes in the land cover.

Results and discussion

Land Cover Compliance

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

Table 1. Classification of Land Cover.

No	Land Cover Classification
1	Forest
2	Planted forests
3	Plantations
4	Water Body
5	Rice fields
6	Mangrove
7	Ponds
8	Bush (shrubs)
9	Dryland Farming
10	Open Land
11	Settlement

This research uses spatial data of land cover that is used in 2014 based on land cover classification in Satui watershed.

The result of suitability is 92%, which means that from 50 test points, there is a mistake of 4 points which include the point of field taking with small coverage whereas on the classification with a wide scope so that classification information using a wide scope and possibly less precisely when digitized image map.

Change of Land Cover in Satui River Basin Year 2000-2014

Based on the data processing presented in Figure 1, it will be known that the process of land cover changes in Satui watershed in the period of 2000, 2003, 2006, 2009, 2011 and 2014 consisting of eleven predefined sample classifications. Here Table 2 sample classification in the Satui catchment:

Based on the table of land cover change, it can be seen the details of the change of land cover of Satui watershed based on eleven of land cover appearance as follows.

Forest

Changes in forest cover are allegedly affected by plantation activities and are partially affected by dry land and open land agriculture. The time period of 2000-2003 condition tends to decrease as wide as 898.50.

In the period of 2003-2006 the area decreased by 14, 102, 08 ha to 21,608.44 ha from 2006-2009 tended to increase of 0.377,56 ha to 31, 986, 00 ha, from 2009-2011 there was a decrease of 44, 14 ha to become 31,941.86 ha and from 2011-2014 there was a decrease of 34, 80 ha to 31, 907, 06 ha. From 2000-2014 there was a decrease of 4,701.96 ha. The change in forest cover decreases due to the increase of plantation forest, plantations and open land which is allegedly the result of the decrease of forest area, this is because there has been no effort so far to manage the dynamics of land use and land cover (Matsa and Muringaniza, 2010).

Plantation Forest

The plantation forests in this study is a land cover with rubber and acacia plant species. Based on the results of data processing conducted in 2000 the plantation has an area of 2,117.00 ha in the period of 2000-2003 increased 124.85 ha to 2,241.85 ha in the period 2003-2006 again increased by 3,069,05 ha to 5,310 , 89 ha in the period 2006-2009 there was a reduction of 4,052.90 ha to 1,257.99 ha in the

period 2009-2011 did not change with the same area and in the period of 2011-2014 there was a reduction of approximately 134.55 ha to an area of 1,123.45 ha.

Plantation Farms

The development of plantation cover in 2000-2003 increased the area from 2,574.13 ha 1,551.17 ha to 4,125.29 ha in the year of 2003-2006 happened again increase of extent of 3,867.54 ha to 7,992.84 ha in year 2006-2009 there was a reduction of land cover of plantation of 2,068.93 ha to 5,923.90 ha in 2009-

2011 did not change still with the same area and in know 2011-2014 there was an increase of very significant extent of 5,491.66 ha to 11,415.56 ha . The increase in plantation area is influenced by the development of plantation areas in 2011 which previously was shrubs and dry land farming, this also happened to Zimbabwe where land change happened from the reduction of forest land cover and agriculture changed to plantation and settlement land. (Chenje *et al.* 1998).

Table 2. Changes in Land Closures Period from 2000 to 2014.

No.	Land Cover	Land Cover	Land Cover				Information
			2006	2009	2011	2014	
1	Forest	Forest	21.608,44	31.986,00	31.941,86	31.907,06	The development of land cover in the Satui watershed tended to change in the area, from 2000 to 2014 changes in the area of land cover increased and there was a decrease that was affected by the use and utilization of land
2	Plantation Forest	Plantation	2.241,85	5.310,89	1.257,99	1.123,45	
3	Plantation	Plantation	4.125,29	7.992,84	5.923,90	11.415,56	
4	Water Body	Water Body	359,78	359,78	359,78	459,63	
5	Rice fields	Rice fields	95,23	95,23	-	-	
6	Mangrove	Mangrove	768,17	1.338,95	301,42	299,75	
7	Ponds	Pond	11,17	-	21,89	21,89	
8	Shrubs	Shrubs	23.485,84	29.726,11	19.217,46	16.058,09	
9	Dry land Farming	Dry land	11.714,71	4.309,21	11.293,33	8.523,79	
10	Open Ground	Open	2.301,73	10.072,83	10.452,52	11.004,34	
11	Settlement	Settlement	314,71	314,71	314,71	315,45	
Amount			81.129,00	81.129,00	81.129,00	81.129,00	

Water Body

The body of water in this study is more on the appearance of the river. Based on the results of research conducted by water body condition in 2000, 2003, 2006, 2009 and 2011 did not change except in 2014 the addition of 99,85 ha to 459,63 ha from 359,78 ha. Increasing the water body area is affected by the condition of land that has been opened for mining activities, thus leaving a mine hole that flooded with water.

Rice fields

Based on the results of research conducted, in the period 2000 to 2003 an increased in the area of 72.51 ha to 95.23 ha. Then in the period of 2003-2006 there is no change in area and the period to 2009, 2011 and 2014 there is no closure of paddy fields.

The loss of land cover in the form of paddy fields is influenced by the condition of land that has been changed to dry land farming, so that the closing of paddy field land in the period of 2009, 2011 and 2014 changed to dry land farming.

Mangrove

Based on the results of research and observation in the field of mangrove is in Satui Timur Village District Satui living in the river estuary Satui around the bush. In the period of 2000-2003 the mangrove area increased by 284.90 ha from the year 2000 of 483.27 ha to 768.17 ha in 2003. In 2003- 2006 the mangrove condition grew by 570.78 ha to 1,338.95 Ha. In 2006-2009 the condition of mangrove experienced a large decrease of 1.037,53 ha to 301.42 ha. In 2009-2011 mangrove condition decreased by 1.67 ha to 299.75

and in 2011 to 2014 the mangrove condition did not change that is equal to 299, 75 ha. Changes in mangroves were allegedly caused by the influence of oil palm plantation activities. As well as increased human activity which is the main cause of land use change and land conversion (Singh and Kumar, 2012).

Ponds

The area of ponds acquired in the year 2000 has not been a pond in Satui watershed. In 2003 there was a pond of 11.17 ha. In 2006, the location of ponds was changed to open land area for mining activities then in 2009, 2011 and 2014 there was a pond of 21,89 ha. Changes in land cover in the form of ponds are indicated because of the mining activities that affect the change of ponds. Changes in pond activity is very significant due to the logging of third party activities in the form of mining activities around the pond area.

Shrubs

The results of research conducted, in the period 2000-2003 shrubs decreased by 1,199.37 ha to 23,485.84 ha which previously had an area of 24,685.21 ha. The period of 2003-2006 shrubs increased by 6,240.27 ha to 29,726.11 ha in 2006-2009 shrubs with a graded rate of 10,508.66 ha, in 2011 for the shrubs did not change and in the period 2011-2014 the undergrowth experienced decrease of 3,159.37 ha. The analysis of shrub changes in 2006-2009 changed from shrub to forest, plantation and open land.

Dry land Farming

Results of research conducted in the period 2000-2003 there was a decrease in area from 12,826.53 ha to 11,714.71 ha for 1,111.82 ha. the period of 2003-2006 was a very large decrease of 7,405.50 ha to 4,309.21 ha. Then the period 2006-2009 there was a re-addition of 6,984.12 ha to 11,293.33 ha in 2009-2011 did not change still remain with the same area and in the period of 2011-2014 there was a decrease of area of 2,769.54 ha to 8,523, 79 ha. the tendency to decrease the cover of agricultural land of dry land which is much influenced by land conversion such as open land and shrubs.

Open Land

Open lands have shapes and patterns that spread among forests, settlements, mines, plantations and roads that are the effect of land clearing.

The condition of open land in 2000 has an area of 1,131.65 ha, then in the period 2000-2003 has increased the area up to 1,170.08 ha. Period between the years 2003-2006 occurred the addition of a very large area of 7,771.10 ha to 10,072.83 ha next in the period 2006-2009 again the addition of extents of 379.69 ha to 10, 452.52 ha in the period 2009-2011 there was very little addition of 45,81 ha to 10,498.33 ha and in the period of 2011-2014 there was another addition of 506,00 ha to 11,004,34 ha.

The change in land cover for open land per period is always increasing in extent along with the increase of population and the need for people around Satui watershed area. Similarly, companies that conduct activities in the area of DAS Satui also greatly affect the change and addition of open land area. Development and population growth and growth economics have transformed land cover into an open landscape so special handling is needed to control it (Anil *et al.*, 2011).

Settlement

Results of research conducted in the period 2000-2003 residential area decreased area of 4.99 ha from 319.69 ha to 314, 71 ha. In the period 2003, 2006, 2009 the settlement did not change until the year 2011 residential conditions are still in a stable state with the same area. Then in 2014 the settlement increased by 0.75 ha to 315.45 ha.

Conclusion

Based on the research that has been done can be drawn conclusion: Compliance of land cover in Satui watershed between spatial data of land cover (GIS interpretation) with 92% suitable field conditions and 8% unsuitable. Changes in land cover incurred during the periods of 2000, 2003, 2006, 2009, 2011 and 2014 in the Satui basin are in general the change of function over each period affected by increased plantations, plantations and open land.

Based on the results of research, discussion, and some conclusions, it can be put forward that changes in land cover in the Satui basin are mostly of plantations and land clearing, it is advisable that monitoring should be done to avoid their expansion. Decrease in forest area that occurred to be an evaluation of local government related to development policies in the region. Accuracy of field results generated actually represent 80% of the reality of the situation, it would be better to carry out field ground checks before spatial data is issued on land cover by agencies in order to obtain more accurate results that are indicate close to 100% of the ground situation.

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