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by Eddy Ibrahim

Submission date: 05-May-2023 02:53PM (UTC+0700)
Submission ID: 2084899997
File name: Land_Cover_Changed_Analysis_in_Ogan_Watershed,_South_Sumatra.pdf (1.06M)
Word count: 2845
Character count: 14617

Indonesian Journal of Environmental Management and Sustainability
e-ISSN:2598-6279 p-ISSN:2598-6260

IJEMS

Research Paper

Land Use-Land Cover Changed Analysis in Ogan Watershed, South Sumatra During 2014-2019 Period

Utari Hikmah Pratiwi[1]*, Eddy Ibrahim[2], Edward Saleh[3], Ngudiantoro[4]

[1] *Graduate School, Universitas Sriwijaya, Palembang 30139, Indonesia*
[2] *Mining Engineering Department, Universitas Sriwijaya, Inderalaya 30662, Indonesia*
[3] *College of Agriculture, Universitas Sriwijaya, Inderalaya 30662, Indonesia*
[4] *Mathematics Department, Mathematics and Natural Sciences Faculty, Universitas Sriwijaya, Inderalaya 30662, Indonesia*
***Corresponding author e-mail**: hikmah.utari@yahoo.com

Abstract

Land use-land cover (LULC) is one of the indicators commonly used in monitoring the quality of natural resources. Most of the Ogan watershed is a peat ecosystem that plays an important role in maintaining the balance of the ecosystem and water supply. During the 2014-2019 period the Ogan watershed experienced several wildfires and infrastructure development, particularly freeways. This study aims to analyze changes in the LULC in the Ogan watershed during the 2014-2019 period. LULC analysis uses remote sensing technology by utilizing Sentinel and Landsat satellite imagery data. LULC identification used the visual image interpretation method, while LULC changes were analyzed using the GIS technique with the spatial overlay method. The results showed that changes in LULC led to the LULC managed class, where the increase in area occurred in the rubber and oil palm plantation classes. Meanwhile, the highest reduction in area occurred in the dry land forest class. Changes in LULC that occurred during the observation period had a negative impact on the watershed in the form of land degradation, decreased levels of biodiversity and increased fire vulnerability. Based on these results, land use in the Ogan watershed needs to be controlled and land management practices must pay attention to environmental sustainability aspects.

Keywords

land use, land cover, land use-land cover changed, remote sensing, GIS

Received: 10 March 2021, Accepted: 1 June 2021
https://doi.org/10.26554/ijems.2021.5.2.53-57

1. INTRODUCTION

A Watershed is an area around a river body that has a conservation function for ecosystem balance (Beucher, 1982 ; Shao et al., 2019). Land use in the watershed area will change the hydrological system and have a negative impact on the ecosystem if it is not managed properly. Watershed areas that are used for built-up areas and infrastructure lead to a reduction in the catchment area and an increase in the volume of rainwater runoff to rivers. Meanwhile, the land conversion of watersheds to agriculture and plantations will cause changes in the hydrological system with the development of canals. An increase in the volume of water run into the river bodies and changes in the hydrological system in the watershed will increase the potential for flooding, especially in downstream areas.

South Sumatra Province is one of the developing and advanced regions in Indonesia, especially Sumatra Island. The South Sumatra region is crossed by several large rivers and has a large peatland ecosystem. Several watersheds in the South Sumatra region are peatland ecosystems that have characteristics of hydrological inundation over years. In recent decades, peat fires in South Sumatra indicate that peat ecosystem management practices still need improvement (Elz et al., 2015 ; Miettinen et al., 2014 ; Miettinen et al., 2011) . The Ogan River Basin is one of the watersheds in the South Sumatra region where most of its area is a peat ecosystem (Wahyunto et al., 2004). The Ogan watershed has an important role for South Sumatra, especially the city of Palembang, which is the downstream area of the Ogan watershed.

The utilization of land in the Ogan watershed area will have an impact on the watershed's hydrological system and increase the potential for flooding in Palembang City, which is the capital of South Sumatra Province. Land use can be identified by LULC analysis using remote sensing technology utilizing satellite image data. Meanwhile, changes in

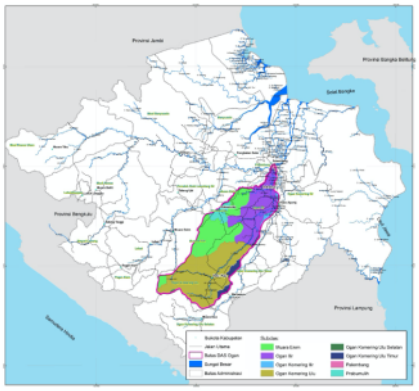

Figure 1. Study Location

LULC within a period can be identified with a GIS technique through the spatial overlay method. This study was designed to identify changes in LULC in the Ogan watershed in the 2014-2019 period. during this period infrastructure, development, and peat fires took place massively (Hooijer et al., 2006; Page and Hooijer, 2016). The freeway infrastructure development in the northern part of the Ogan watershed will certainly affect the watershed area and the downstream area of the watershed (Pratiwi et al., 2021). Meanwhile, wildfires in the study area continued to recur during the observation period with the severe wildfires taking place in 2015 (Huijnen et al., 2016; Putra et al., 2019a). The results of the research in the form of the changing characteristics of LULC are useful as information and a basis for determining management practices for watershed areas and peat ecosystems in the Ogan watershed, South Sumatra.

2. EXPERIMENTAL SECTION

2.1 Study Area

South Sumatra is crossed by several large rivers such as the Ogan River, Musi River, Banyuasin River, etc. The Ogan River basin is one of the watersheds in South Sumatra, which is located in the middle of the province and is directly connected to the city of Palembang. The Ogan watershed area is divided into twelve sub-watersheds with a total area of 841,721 hectares. In the last decades, anthropogenic activities (land use and infrastructure development) have led to the degradation of natural resources in the Organ watershed area (Elz et al., 2015; Turetsky et al., 2015). The Ogan watershed is the location of the research located at longitudes of 103° 30' 0" E and 105° 0' 0" E and latitudes of 02° 50" 0" S and 04° 30' 0" S (Figure 1).

2.2 Methods and Data

LULC is an object in this study identified by remote sensing technology by utilizing satellite image data. In this study, the visual image interpretation method was used to produce LULC maps. Meanwhile, the analysis of LULC changes was identified by using GIS techniques through the spatial overlay method. Next, changes in LULC are studied to determine the characteristics of the changes that took place during the observation period (2014-2019).

This research uses sentinel-2 (2A product level) satellite image data recorded in October 2019. While the Landsat data used is Landsat 7 product level 1 recorded in January-February 2014. The satellite imagery used in this study has a cloud cover below 10%. Sentinel satellite images are obtained from the European Space Agency/ESA website (scihub.copernicus.eu), while Landsat images are obtained from the United State Geological Survey/USGS website (earthexplorer.usgs.gov). Sentinel and Landsat image data processing in this study uses QGIS version 3.16. Sentinel-2 satellite imagery has been radiometric and geometric corrected by the source, then interpreted visually to produce a LULC map. Meanwhile, the radiometric and geometric corrections of Landsat-7 satellite imagery were applied using QGIS software

3. RESULTS AND DISCUSSION

The results of LULC identification at the research location in 2014 were dominated by the LULC type of plantation class. The plantation area covers more than half of the observed area (52% or 412,101 hectares) where the largest plantation type is rubber plantation type which covers at least 30% (241,438 hectares) of the observed area. Besides the plantation class, the LULC type is also dominated by the unmanaged class in the form of dry land forest with an area of 217,000 hectares or 27% of the Ogan watershed area. LULC analysis in 2014 shows that most of the research areas have been used for various utilities (plantation, settlement, road, etc.). Land utilization in the Ogan watershed requires proper control and planning considering that almost all of the Ogan watershed area is a peat ecosystem (based on 2017 data from the Ministry of Environment and Forestry).

The characteristics of LULC in 2019 in the Ogan watershed area were still dominated by the LULC class which was managed (plantation, settlement, road, etc.). The LULC class that is managed reaches around 78% or 612,563 hectares where the rubber plantation class is the largest (41% of the study area). On the other hand, the unmanaged LULC types in the form of dry land forests, shrubs, water bodies, etc. cover 22% of the Ogan watershed area. Dryland forest is still an unmanaged land type with the highest area reaching 139,689 hectares (17% of observation area). The spatial distribution of LULC in the Ogan watershed area is presented in Figure 2.

The LULC changes are the result of a reduction in area for each of the LULC classes in 2019 and 2014. Meanwhile, the percentage change is the ratio between the area of change in LULC to the area in 2014 for each class. During the observation period, changes in LULC took place in two types of changes, namely the addition and subtraction of area.

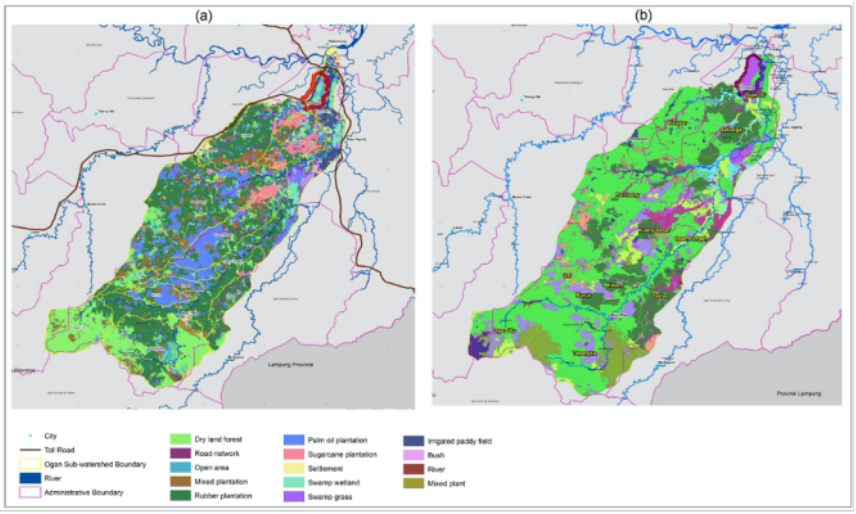

Figure 2. LULC in Ogan Watershed area (a) LULC 2019; (b) LULC 2014

The highest increase in area in the LULC class occurred in the rubber plantation and oil palm plantation classes. The increase in the area of the plantation type indicates the existence of land use efforts in the research location which are included in the South Sumatra peat ecosystem. The increase in the area of rubber plantations reached 35%, while oil palm plantations were around 83% of the area in 2014. The trend of increasing plantation area after the fire period, especially on peatlands, is in accordance with the results of previous studies (Miettinen and Liew, 2011 ; Miettinen et al., 2012), where the fire is used as a tool to prepare land for managed LULC (plantation) class. During the observation period, the study location which was dominated by peatlands experienced several fires with severe fires in 2015 (Putra et al., 2019a ; Putra et al., 2019b). Based on the function of the Ogan watershed, an increase in the area of plantation has a negative impact on watershed management practices because the changes that occur will affect the natural hydrological conditions of the Ogan watershed.

On the other hand, the change in LULC in the dry land forest class became the highest reduction in area at the study location. At least 36% of dryland forest area decreased during the 2014-2019 period. Spatially, the decrease in dry land forest area was caused by an increase in the area of the plantation, in other words, most of the dry land forest classes were converted to rubber and oil palm plantations. Land conversion from natural type (forest cover) to managed land requires land engineering, especially in the hydrological planning and vegetation planting sections. Changes in hydrological systems and vegetation that tend to be homogeneous have resulted in decreased biodiversity at the conversion area. The decrease in the level of diversity certainly has a negative impact on the sustainability of the ecosystem in the research area.

The development of road infrastructure (road network class) is identified in the Ogan watershed, where the area of the road network in 2019 increased compared to 2014. An increase in the area of the road network was identified in the construction of the Palembang-Indralaya (Palindra) freeway on the north side of the Ogan Watershed area. The LULC type before the freeway was built was bush, swamp, and water body (river) class. The existence of the Palindra toll road causes the peatland ecosystem in the area to become drier in the dry season, so that the level of fire prone is higher (Pratiwi et al., 2021; Putra et al., 2019b). A recapitulation of changes in LULC at the study location is presented in Table 1.

4. CONCLUSIONS

Changes in the LULC that took place in the Ogan Watershed area during the 2014-2019 period mostly led to the type of managed LULC (plantation). The results of spatial analysis related to changes in LULC which are associated with a literature review show that the changes are negative. Changes in LULC have resulted in land degradation, decreased levels of biodiversity and increased potential for fires. In addition, changes in LULC are indicated to use fire as a tool of land preparation. This certainly contributes to climate change where fires will emit carbon into the atmosphere (Latif et al., 2018 ; Page et al., 2002). Based on the research results, changes in the LULC in the Ogan watershed need to be controlled. On the other hand, land management practices in plantations and agriculture need to pay attention to environmental sustainability aspects to avoid negative impacts.

Table 1. Recapitulation of LULC changed in Ogan Watershed area

Land Use/ Land Cover	Area (Ha)		Changed	
	2014	2019	Ha	%
Dry Land Forest	217,000	139,689	-77,311	-35.63
Road Network	521,000	1,151	630,000	120.92
Open area	53,996	18,973	-35,023	-64.86
Mixed Plantation	62,593	75,442	12,849	20.53
Rubber Plantation	241,438	327,492	86,054	35.64
Palm Oil Plantation	66,588	121,872	55,284	83.02
Sugarcane Plantation	41,482	31,831	-9,651	-23.27
Settlement	16,167	28,312	12,145	75.12
Swamp Wetland	2,732	4,443	1,711	62.63
Swamp Grass	2,668	13,184	10,516	394.15
Irrigated Paddy Field	8,345	2,803	-5,542	-66.41
Bush	48,521	8,098	-40,423	-83.31
River	5,711	4,433	-1,278	-22.38
Mixed Plant	26,493	4,687	-21,806	-82.31

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