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MORALITY BEFORE KNOWLEDGE

Impact analysis of forest and peatland landscape change: Socio-economic and environmental implications

Muhammad Diheim Biru[1]*
[1] *School of Environmental Science Universitas Indonesia; Jakarta, 10430, Indonesia.*
*Correspondence: muhammad.diheim11@ui.ac.id

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ABSTRACT

Background: Peat forest land is highly susceptible to burning and releasing stored carbon and greenhouse gas emissions into the earth's atmosphere when its water content is used for plantations, agriculture and other uses. This study was conducted to analyze the progress of forest and peatland landscape development in Katingan District, Central Kalimantan Province and its potential ecological impacts on the environment. **Methods:** This research approach uses a quantitative approach to analyze landscape changes that occur within five years, namely in 2015 and 2020. The research was conducted by examining secondary data only. **Finding:** The results of this study show that the contrast in land increase between forest and peat land and non-forest land is not significant, as shown by the ratio of forest and peat land/non-forest land which increased by only 0.02 or 2% between 2015 and 2020. If the area of non-forest land continues to increase in the future, Katingan Regency is predicted to have a higher vulnerability to natural disasters. **Conclusion:** The results of land cover/landscape change in Katingan District, both forest and peatland (consisting of primary dry forest, secondary dry forest, secondary mangrove, swamp, swamp scrub, and secondary swamp forest) and non-forest land, both increased in area, respectively by 26,532.61 ha and 4813.64 ha from 2015 to 2020. **Novelty of This Study:** This study provides a unique perspective on the ecological impact of land cover changes in Katingan District by analyzing a five-year landscape transformation using a quantitative approach.

KEYWORDS: land cover, ecology, peatland, katingan, change

1. Introduction

Indonesia is one of the countries with the largest peat forest land with the potential to store a lot of carbon stocks in the world, especially on the islands of Sumatra, Kalimantan, Papua and Sulawesi (Qirom et al., 2018). In the last decade, the international community has been paying attention to peatlands and their carbon cycle because of their ability to store carbon or release carbon into the atmosphere due to land burning at high levels (Posa et al., 2011). The phenomenon of climate change has prompted the international community to invest in the protection of natural forest lands and peatlands due to the loss of many of these lands that were supposed to be the world's carbon stocks or sinks, and over the same period, the increase in average carbon dioxide greenhouse gas emissions that contribute to global warming or an increase in global surface temperatures (World Bank, 2006). Peatlands have been subject to landscape change as a result of use for oil palm and Acacia plantations. These plantations require significant drainage and water absorption, which affects not only the water table in the soil on the converted land, but also the surrounding peatlands. This absorption eventually leads to peatland drainage, which results in the

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release of high levels or emissions of CO_2 (Sumarga et al., 2016). To prevent further changes to the peat forest landscape, it is necessary to know what existing landscapes still exist and how much they have increased or decreased in recent years.

The landscape is a system that is not only characterized by the physical system and biological system, but also strongly influenced by the presence of the human system. The presence of humans as actors in the management and utilization of landscape contributes greatly to changes in landscape structure. Various landscape utilization activities such as agriculture, forestry, fisheries and settlement development have the potential to cause landscape dynamics over time. Analysis of landscape dynamics is important, among others, to evaluate the impact of landscape management activities that have been and are being carried out, as well as to design landscape utilization optimization (Harden et al., 2014). There is a need for research that can evaluate landscape change, especially in areas rich in peat forest land such as Central Kalimantan Province. One of the areas in the province that has a significant area peatland is Katingan Regency, as there are efforts to restore the land from the private sector with the Katingan Mentaya Project restoration forest concession (Hartono, 2020). In research this research, formulated problem that is researched includes variables related to landscapes and their large carbon storage such as natural forest land and peat swamp in Katingan District and non-forest variables that can be compared, which will then be analyzed for the comparison of the portion of the area between the lands and compared change landscape landscapes from year that pre-determined year. The contrast of land differences between primary and secondary forests and non-forested, human-used land can show the impact on biodiversity resources and carbon stock intensities that are owned by the region. Research on these variables is useful analyzing the extent of landscape changes that have occurred in the past five years and analyzing the ecological and social impacts of these changes, especially in terms of carbon emissions.

The research questions addressed in this study focus on three key aspects: the increase in forest and peatland area in Katingan Regency between 2015 and 2020, the increase in non-forest land area within the same period, and the ecological and social impacts resulting from these changes. Broadly speaking, the aim of this research is to gain an overview of the progress of landscape development and its ecological impact on the environment. Specifically, the objectives of this research will be derived from the previously stated research questions, which are more operational in nature and will be answered at the end of the research. Thus, the objectives of this research are to (1) determine the amount of change in forest and peatland area that occurred in Katingan Regency between 2015 and 2020, (2) determine the amount of non-forest land area change that occurred in Katingan Regency between 2015 and 2020, and (3) Predicting the ecological and social impacts that could occur in the future based on changes in forest and peat land area and non-forest land that have occurred in Katingan District from 2015 to 2020. By achieving these objectives, this study seeks to contribute valuable insights into the environmental consequences of land use changes in Katingan Regency.

1.1 Urban ecology

In a study of change, there are basic sciences that need to be used as research guidelines so that the analysis carried out remains in accordance with the rules of the spatial science field under study. There are several sciences that can be used as a basis for this research, namely urban ecology, ecosystems, space, deforestation, peatlands, carbon emissions, and land cover. First urban ecology, urban ecology is a multi-dimensional topic. This topic includes social, economic, and environmental dimensions related to sustainable development. In addition, in conducting urban ecology discussions, various experts are quite involved in the process. In cases related to ecology in developing countries, these countries encourage the urbanization process with economic interests. This case is inversely proportional to the process that occurs in developed countries. Developed countries are more concerned with how urban development does not affect the environmental ecosystem.

Urban ecology basically applies a variety of human ecology concepts to the urban realm. The city is understood as an ecosystem with various areas within the city undergoing processes of invasion and succession. An example of its application can be seen in the movement of migrant populations, particularly in relation to parts of the city that are home to waves of groups from different backgrounds moving through an area.

After the Habitat Conference in Stockholm in 1972, urban studies were declared to be an important part. The use of several terms 'urban ecology' has been expressed as a concept of balance, such as ecological city which refers to a city in balance with nature. The development of urban ecology as expressed in geographic literature has gone well beyond traditional human ecology. It includes population, technology, organization and environment as important variables used in the study of people in cities.

Urban ecology can therefore be defined as the study of the distribution, abundance and behavior of organisms interacting with each other and their environment. Ecology encompasses many organisms within individuals, populations, communities and entire ecosystems. However, urban ecology also studies urban environments, especially those affected by development, expansion and operations, such as forests (water reservoirs) that supply drinking water to urban residents. In addition, urban ecology also involves people because the presence, population dynamics and behavior of people, as well as the environmental changes that occur as they build cities, are important and relevant in understanding how urban systems function (Parris, 2016).

1.2 Peatland and deforestation

Peatlands are defined as saturated ecosystems consisting of deposits of partially decomposed organic matter, or peats. These wetland systems provide a variety of valuable ecosystem services, such as regulation of water flow, habitat for threatened animals such as orangutans, Sumatran Tigers and proboscis monkeys, as well as native trees, and are also one of the largest carbon sinks. Peatlands have been recognized by the World Climate Conference for their ability to store large amounts of elemental carbon from the atmosphere and emit organic carbon when these ecosystems are disturbed (Saragi-Sasmito et al., 2019). In recent decades, many peatlands have been disturbed and converted by human needs. Much of the degradation that has occurred has been caused by the increasing land expansion needs of industrial plantations, such as palm oil and pulpwood (Gaveau et al., 2016).

Then deforestation is the loss or degradation of forest habitat caused by nature or man. In general, deforestation is caused by the massive conversion of forest land to be utilized by the people communities, such as for oil palm plantations following the government's policy to increase export earnings and higher international prices in 1990-1997. Specifically, the drivers of deforestation and land degradation are complex and multifaceted. There are two drivers of deforestation: direct and indirect. Direct drivers include uncontrolled and frequent logging activities, illegal logging and forest fires, especially due to the prolonged dry season. Indirect causes include market failures (e.g. setting timber prices too low), policy failures (e.g. granting HPH permits that for 20 years did not produce incentives for reforestation and transmigration programs), government weaknesses in law enforcement, and other socio-economic and political issues such as the economic crisis, the reform era, high population density and growth, and the uneven distribution of economic and political power (Nawir et al., 2008).

In general, vegetation cover in a neighborhood or urban area will decrease as the human population density and/or development density increases (Pauchard et al., 2006). On the other hand, Indonesia's population continues to increase from 119.21 million in 1971 to 258.50 million in 2016 with an average annual growth rate of 1.98% (1980-1990) and 1.36% (2010-2016) (Badan Pusat Statistik, 2018). By 2030, Indonesia's population is predicted to increase to around 296.4 million with an average annual growth rate of 0.98%

(BPS, Bappenas, UNFPA, 2018). In addition, Central Kalimantan Province has lost 24% of its forest land cover since 2000 and has generated 1.32 Gt (Gigatonne)of CO2 emissions from 2001 to 2019. The rate of deforestation varies across Central Kalimantan Province, but one of the five districts experiencing the highest loss of forest cover is Katingan District. From 2002 to 2019, the total loss of forest land cover in Katingan amounted to 64%. A report by (World Bank, 2006) shows that inappropriate implementation of past Indonesian government policies contributed to these problems and global warming. The causes include the growth and development of the wood processing industry (pulp and plywood), land conversion, and land use change.

The rapid and subsidized conversion of forests to oil palm and timber plantations, and local corruption and collusion for accumulated land use permits. All these factors make biodiversity-rich lands poor in ecosystem services and natural regulators of the environment, such as those currently on the islands of Sumatra and Kalimantan. As a result, much of the elemental carbon that should be stored by these lands is released into the atmosphere, resulting in increased average greenhouse gas emissions and rising global surface temperatures. In the second BUR (Biennial Update Report) data compiled by (Boer, et al., 2018), Indonesia produced carbon dioxide levels that increased by 42.14% in 2016 compared to those produced in 2000. In the same year, the carbon dioxide levels produced mostly came from the FOLU (Forestry and Land Use) sector, which amounted to 43.59%, followed by the energy sector at 36.91%.

1.3 Carbon emissions and cover/land Cover

2021 IPCC working group one report by (Masson-Delmotte et al., 2021) revealed that since 2011, the concentration of carbon dioxide (CO2) compounds observed in the Earth's atmosphere has continued to increase, reaching a level of 410 ppm per average year. Warming has been attributed to human activities and greenhouse gas emissions, the two largest factors contributing to the increase in global temperature, which is estimated to have increased by 1.07°C degrees globally between the period 1850-1900 and the period 2011-2020. Greenhouse gas emissions, in this case dominated by carbon dioxide, mix into the atmosphere and contribute to warming that ranges from 1.0°C to 2.0°C. It is likely that greenhouse gas emissions mixing with the atmosphere is the main driver of atmospheric warming, especially in the troposphere since 1979, contributing to the increase in air temperature.

Then based on Law No. 4 of 2011 on Geospatial Information, land cover is a line that describes the boundaries of the appearance of cover areas on the earth's surface consisting of natural landscapes and/or artificial landscapes. Meanwhile, according to (National Standardization Agency, 2010), land cover is the observable biophysical cover on the earth's surface that is the result of human arrangements, activities, and treatments carried out on certain types of land cover to produce, alter, or maintain the land cover. On a national scale, land cover has 22 classes, of which there are specifically seven classes for forest cover and 15 classes for non-forest cover.

1.4 Space

Space is a place on the earth's surface, either entirely or only partially used by living things to live. Space can also be interpreted as a container of all human, animal, and plant activities on the earth's surface. Space is not only limited to the air that comes into contact with the earth's surface, but also the lowest layers of the atmosphere that affect the earth's surface. Space also includes waters on the earth's surface, namely seas, rivers, lakes, or those below the earth's surface (groundwater) to a certain depth (Nursid, 1988). Based on the context of legislation, according to Law No. 26 of 2007 concerning Spatial Planning, space is a container that includes land space, sea space, and air space, including space within the earth as a unified area, where humans and other creatures live, carry out activities, and maintain their survival. In Law No. 32 of 2009 Article 1 concerning Environmental

Protection and Management, space is included in the definition of the environment, namely the unity of space with all objects, forces, conditions, and living things, including humans and their behavior, which affect nature itself, the continuity of life, and the welfare of humans and other living things. The Ministry of Environment and Forestry of Indonesia (2021) states that a concept is needed that can explain the relationship and interaction between units of a resource in space. The development of science and the natural resource management problems that have been encountered have opened up management to refer to the concept of ecosystems. The types of ecosystems vary widely, so a clear classification and delineation between their boundaries is required.

1.5 Ecosystem

Based on the understanding of ecology, the various systems formed in nature are the basic units of life on earth. Humans basically have a tendency to prejudge that life is an important component in a system. However, inorganic factors also have an equally important role. When excluding an inorganic system, the system cannot exist, because every ecosystem has a constant exchange of matter and energy, both between organisms and between organic and inorganic components.

As we mentioned, telar ecosystems are present among humans in various forms and scales. This ranges from the smallest forms of presence to the broadest forms of presence, as cosystems are part of a larger category of physical systems in the universe that vary in scope from atomic to cosmic scales. An ecosystem or ecosystem for short is defined by (Tansley, 1935) as a collection of living and non-living components found in a particular place or geographical area and the interactions that occur between them. Therefore, an ecosystem has four major elements: living elements consisting of all organisms, from the smallest microbes to the tallest trees and largest animals; non-living elements consisting of air, water, light, heat, and minerals (in the form of rocks, soil, sand, dust, carbon, and other nutrients); interactions within and between the first two elements; and a defined physical space in which all these elements are located (Keith et al., 2013).

This article will probably discuss ecosystem instability and small forms of change in vegetation that may be difficult to observe, but still take place over time. However, the relative instability in ecosystems is essentially due to their imperfect balance with varying degrees of instability. Through these conditions, humans can appreciate and measure them in a simple way. Basically, one system such as climax vegetation appears to be stable over a period of time when observed carefully. However, in reality change does occur, albeit on a scale so small that it is difficult for an observer to detect. With this in mind, ecologists argue that all vegetation is subject to change. Even small changes in the ecosystem do not necessarily lead to its destruction. Humans as a whole must still understand that climate factors are one of the determinants in the ecosystem. For this reason, humans must be aware of significant climate change, because it can cause disruption to the ecosystem of a geographical area. As a result, existing ecosystems may be transformed or even replaced by others that are better suited to the new climatic conditions.

2. Methods

This research approach uses a quantitative approach to analyze landscape changes that occur within five years, namely in 2015 and 2020. The research method uses quantitative methods. The research was conducted by examining secondary data only. The source of secondary data collection is from the Indonesian Rupabumi base map and land cover data from the Ministry of Environment and Forestry of the Republic of Indonesia (KLHK) in the Katingan Regency area, Central Kalimantan Province, Indonesia in 2015 and 2020. Beyond that, secondary data processing was carried out with the ArcGIS spatial data processing program version 10.2. ESRI's spatial data processing program, especially for calculations, processing, and map layouting using the ArcMap program.

The research was conducted from November 19 to December 07, 2021. The research location was Katingan Regency, Central Kalimantan Province, Indonesia. Based on Law Number 5 of 2002, Katingan Regency is included in Central Kalimantan Province, with the capital city being Kasongan. Kasongan City is located within the Katingan Hilir District. Based on the Regulation of the Minister of Home Affairs of the Republic of Indonesia Number 137 of 2017 concerning Codes and Data for Government Administration Areas, Katingan Regency has an area of 17,500 km2. However, a study of the determination of administrative boundaries that has been carried out by the Regional Government of Katingan Regency, assesses that the area of Katingan Regency until 2019 is 20,393.7 km2. Geographically, Katingan Regency is located between 0º20'-3º38' South latitude and 112º00'-113º45' East longitude. In the north, Katingan borders Malawi Regency; in the east, it borders Gunung Mas, Palangkaraya, and Pulang Pisau Regencies; in the south, it borders the Java Sea; and in the west, it borders Kotawaringin Regencyl and in the east, ir borders Seruyan. Furthermore, Katingan Regency consists of 13 sub-districts, namely Katingan Kuala, Mendawai, Kamipang, Tasik Payawan, Katingan Hilir, Tewang Sangalang Garing, Malan Island, Katingan Tengah, Sanaman Mantikei, Petak Malai, Marikit, Katingan Hulu, and Bukit Raya. The district is crossed by the Katingan River, which has a length of ± 650 km with many tributaries (Central Bureau of Statistics, 2021).

The following is a map of the research location with information on its administrative area based on the 2017 Indonesian Rupabumi base map data. This map is a map of the administrative area of Katingan Regency, Central Kalimantan Province, that describes the sub-district boundaries, water networks, and road infrastructure in the area. Katingan Regency consists of several sub-districts which are displayed with different colors to distinguish their respective administrative areas. In addition, this map also shows rivers as part of the water network that has an important role in transportation and the lives of local communities. Based on this information, this map can be used as a reference in development planning, regional management, and geospatial analysis in Katingan Regency.

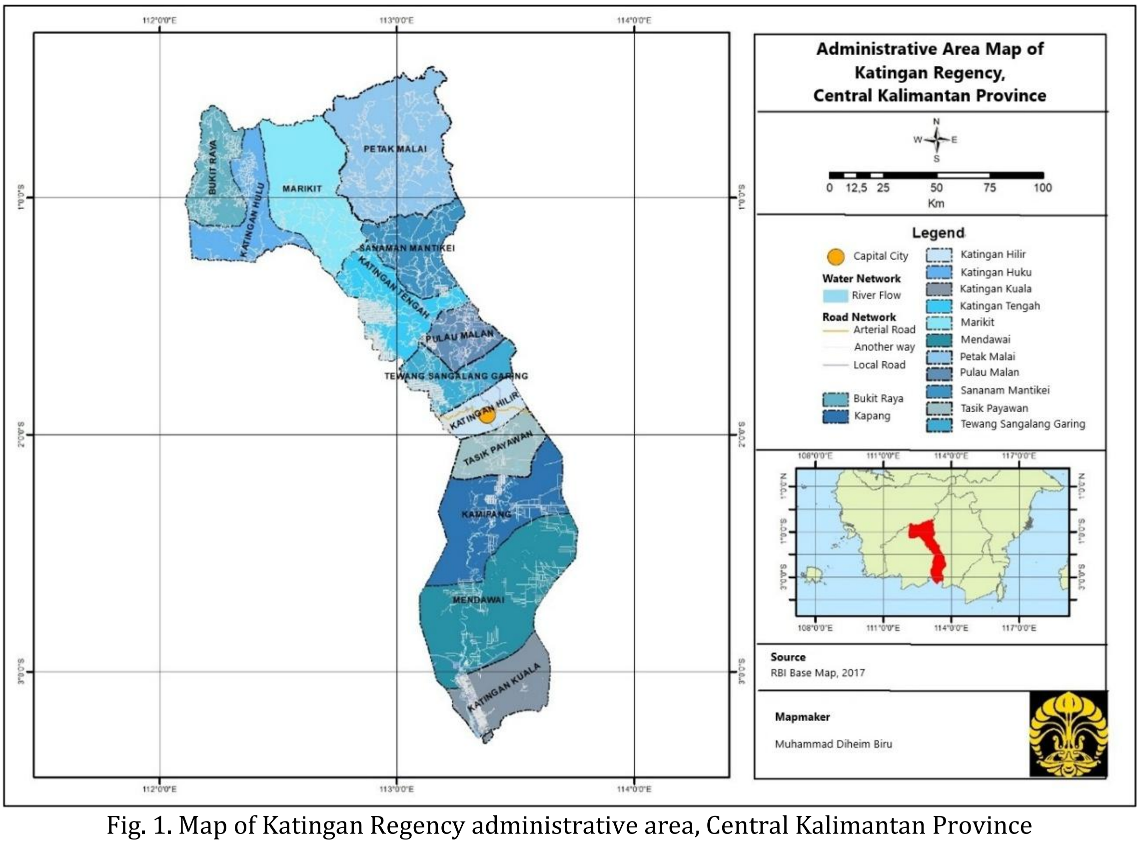

Fig. 1. Map of Katingan Regency administrative area, Central Kalimantan Province

The analysis method used in this research is map comparison and literature review. Specifically, by comparing the processed land cover data on the research map within five different years and discussing the analysis of the differences between the two land covers by reviewing data and statements from journals and other data sources that have been collected to answer the research objectives. The analyzed differences in land cover will show the development of landscape change in Katingan District and the development of land cover change in Katingan District indicate the likely impacts incurred, both ecologically and socially.

Based on the reference document related to land cover from (Ministry of Environment and Forestry, 2021), The Ministry of Environment and Forestry of Indonesia's digital land cover data is the result of the interpretation of LDCM (Landsat Data Continuity Mission)/Landsat 8 OLI images classified into various classes. From this classification, lands categorized into the forest class are primary dryland forest, secondary dryland forest, primary swamp forest, secondary swamp forest, primary mangrove forest, secondary mangrove forest, and plantation forest. Meanwhile, land categorized into the non- forest class is land that is not previously mentioned above, namely plantations, shrubs, swamp shrubs, dryland agriculture, mixed dry agriculture, rice fields, settlements, transmigration settlements, open land, mining, water bodies, and swamps.

For data analysis in this study, land cover will be categorized into two, namely forest and peat land (primary and secondary natural forest designations, including swamp and peat) and non-forest land (plantation, agriculture, other uses, and open land). Forest and peatland and non-forest land are categorized based on human access to the area, where forest and peatland are places that have high biodiversity and carbon stocks and provide diverse natural ecosystem services, while non-forest land is a place that often has human presence and is often used for human needs. Then, swamp and swamp scrub land is included in the forest and peat land group because wetlands or swamps in Central Kalimantan Province can contain peat and function as a store of decomposed organic matter and high levels of elemental carbon, so they need to be included in the land group that needs to be conserved given the country's commitment to reducing carbon emissions. In addition, for this study, water bodies and shrubs were not included in non-forested land for the purpose of comparison in terms of their broad ecological functions, as water bodies can be traversed by forested lands and shrubs can function ecologically as habitats for wildlife.

3. Results and Discussion

3.1 Land use/land cover map

From the results of the processed land cover map based on The Ministry of Environment and Forestry of Indonesia land cover data in 2020, the lands obtained in Katingan Regency are primary dry forest, secondary dry forest, secondary mangrove forest, plantation forest, swamp scrub, swamp, shrubs, plantations, dry land agriculture, dry land agriculture mixed with shrubs, rice fields, settlements, mining, transmigration settlements, open land, and water bodies. As for land cover data in 2015, no transmigration settlement land was found. Several land covers in this study were combined into one in the processed map to facilitate the classification between forest and peatland and non-forest land according to their general ecological functions. In the processed map, forest and peatland are represented by three cover categories, namely secondary swamp forest, swamp scrub and swamp, which are combined into Secondary Peat Forest and Peatland; Primary Dry Forest; and Dry Forest, Secondary Mangrove and Plantation Forest. Meanwhile, non-forest land is represented by four cover categories, namely Plantations; mining, settlements, and transmigration combined under Other Uses; dryland agriculture, dryland agriculture mixed with shrubs, and paddy fields combined under Agriculture; and Open Land. This map is a land cover map of Katingan Regency, Central Kalimantan Province, which illustrates the various types of land use in the region based on The Ministry of Environment and Forestry of Indonesia Land Cover data in 2020. In this map, different types of land cover are classified with different colors, including forests (primary and secondary), agricultural land, plantations, and water areas. This information is useful for understanding the distribution of vegetation, land use, and potential natural resources in Katingan District. With this map, further analysis can be conducted related to land change, environmental conservation, and regional development planning.

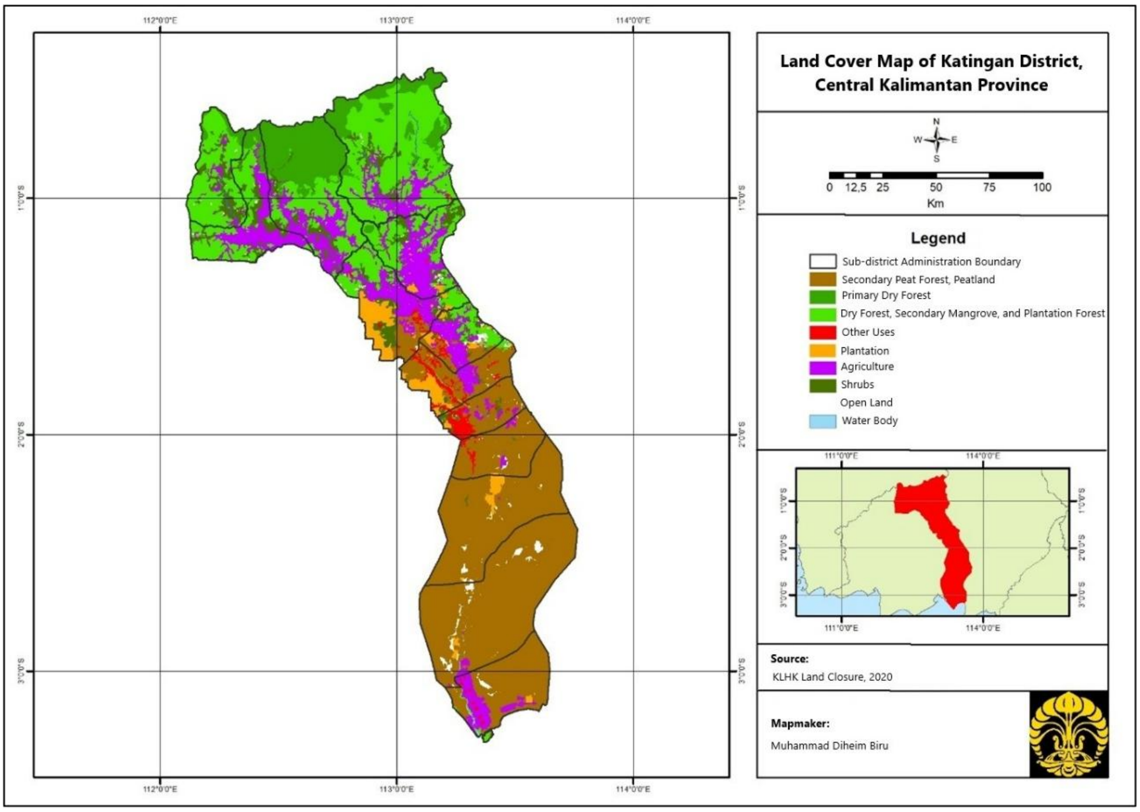

Fig. 2. Land use/land cover map of Katingan District, Central Kalimantan Province

The land use/land cover map data above shows the land cover condition of Katingan Regency in 2020. The land cover condition map above is only a depiction of land cover conditions that are close to the current conditions. It can be seen from the map above that the land cover in Katingan Regency is dominated by wetland cover consisting of secondary swamp forest, swamp scrub, and swamp with a land area of 795,953.71 ha, followed by primary dry forest land, secondary dry forest land, and secondary mangrove which totals 736,321.35 ha. Then, the third largest land is land of secondary swamp forest, secondary dry forest land, and secondary mangrove which totals 736,321.35 ha. Then, the third largest land is agricultural land, which consists of dry land agriculture, dry land agriculture mixed with shrubs, and rice fields with an area of 230,382.5 ha.

3.2 Comparative analysis of 2015 and 2020 land cover maps

Furthermore, to find out the landscape changes in the same category that occurred within five years, an area comparison was made between the land cover map in 2015 and the land cover map in 2020. Then from the difference in area within five years, the possible ecological and social impacts that occur are discussed. The following is a comparison of the land cover layout of the two land use maps used for analysis in this study.

From the two processed land use maps above, it can be clearly seen that there are differences in the landscape of Katingan Regency between the land cover layout in 2015 and the existing land cover in 2020. It is known that from the results of the calculate geometry calculation in the attribute table of each shapefile to calculate the area, there is a difference in results between the total area of Katingan Regency in 2015 and 2020, which is

2,035,414.54 ha and 2,021,048.62 ha, respectively. This difference in area can cause bias, but in the discussion, the comparison and change of landforms will be seen more from the portion or ratio of the comparison between years only and connected to the possible ecological and social impacts that occur.

In summary, in terms of land cover in 2015, the area of forest and peat land consisting of secondary peat forest and peatland; primary dry forest; and dry forest, secondary mangrove, and plantation forest amounted to 1,505,742.45 ha. Then, the area of non-forest land consisting of agricultural land, plantations, open land, and other uses amounted to 359,963.46 ha. It can be said that the ratio of forest and peat land area to non-forest land area in Katingan Regency was 4.18 or four times in that year. As for the area of land cover in 2020, the area of forest and peatland is 1,532,275.06 ha and the area of non-forest land is 364,777.1 ha. It can be said that the ratio of forest and peatland area to no—forest land area in Katingan Regency in 2020 is 4.2. This shows that the portion of forest and peatland area within five years has increased, which is 26,532.61 ha from the difference with the area five years earlier. However, non-forest land has also increased over the five-year period by 4813.64 ha, which is the difference between the two areas. This resulted in the ratio of forest and peatland/non-forest land increasing very slightly by 0.02.

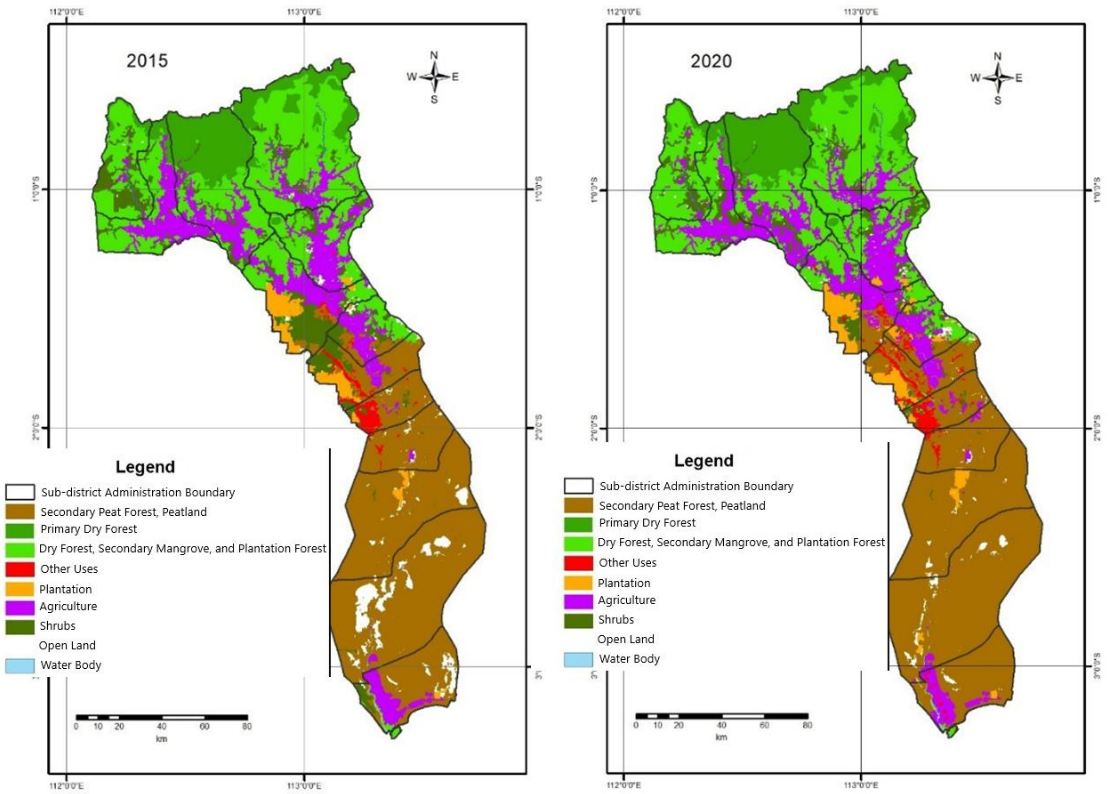

Fig. 3. Comparative analysis of katingan district land use/land cover map 2015 and 2020

This map shows land cover change in Katingan District, Central Kalimantan Province, between 2015 and 2020. Using a comparison of the two maps, it is possible to observe the dynamics of land use change, including forest conversion, plantation expansion, and the development of agricultural land and settlements. The different colors in this map represent different types of land cover, such as peat forest, primary forest, secondary forest, plantations, and water areas. Analysis of this map can provide important insights into the impact of land change on ecosystems, environmental sustainability, and regional spatial planning in Katingan District. Furthermore, for data per land cover according to the legend in the map comparison image above, when viewed with the naked eye, it can be seen that there are clear landscape/land cover changes from 2015 to 2020, especially in the Central Katingan, Mendawai, Tewang Sangalang Garing, and Katingan Hilir sub- districts. In the

Central Katingan sub-district, the shrub land that existed in 2015 was replaced by swamp/shrub land/secondary swamp forest. This land replacement is also supported by the number of shrub land areas in the District which decreased from 2015 to 2020, namely from 152,706.5 ha to 106,272.4 ha. In the Regency, there was also an increase in land area in general, namely in plantation land, other uses, and agriculture, which increased by 26875.87 ha, 9011.38 ha, and 9443.74 ha, respectively. This high increase in plantation land has the effect of not significantly increasing the contrast between forested land for protection and conservation and non-forested land. On the other hand, the open land in the map comparison above appears to be decreasing and replaced with swamp land/shrub swamp/secondary swamp forest, especially in the Mendawai sub-district area. This change is also supported by the reduction in the number of open land areas from 2015 to 2020, which amounted to 40517.36 ha. The area of peat forest and peatland itself from 2015 to 2020 has increased by 55339.07 ha. Broadly speaking, within five years, both variables, namely the area of forest and peatland and non-forest land, have increased by almost the same amount. The magnitude of the increase in land area can be measured by the ratio of forest and non-forest land in 2020 compared to their own conditions in 2015, which amounted to 1.017 and 1.013, respectively.

3.3. Ecological and social impacts of agricultural land

From the results of the data obtained, it can be concluded that in the five-year period from 2015 to 2020, the increase in forest and peatland area in Katingan District does not have a significant ecological impact. This is shown by the small increase in the ratio of forest and peatland/non-forest land, which only increased by 0.02 from 2015 to 2020. This ratio shows that an increase in forest and peatland is accompanied by an increase in non-forest land. From this ratio, it is necessary to assess the impact of the third increase in non-forest land cover of 4813.64 ha, which consists of other uses (mining, settlements, transmigration), open land, agriculture, and plantations.

According to the community in Katingan Kuala Subdistrict in a study conducted by (Mustapa et al., 2019), the ecological impact provided by agricultural land development is considered not damaging to the environment, because it does not change the existing landscape and environmental hue. It is assessed that changes in the existing environmental hue do not cause floods or droughts, because rice fields can accommodate surface water runoff. In addition, animals and plants such as cork fish, halua, and others can still be found in the rice field location. Furthermore, the study conducted a multidimensional analysis of the sustainability of the rice field printing program in Katingan Regency, and produced a value of insufficient sustainability due to the low scores of the infrastructure and institutional dimensions. From the assessment, the economic and ecological sustainability scores were ranked as sufficient, at 57.52 and 65.63 respectively. From the study, it should be noted that agricultural land development needs to be accompanied by sufficient access, capital and facilities for farmers so that the land that has been created can be productive and not idle. On the other hand, commonly used agricultural techniques can have a large impact through land clearing, water absorption through drainage and fertilization, all of which involve burning. Deforestation activities can also result in reduced biodiversity (Wijedasa et al., 2017). In addition, idle agricultural land only disrupts the hydrological cycle of surrounding peatlands and causes drought, leading to vulnerability to disasters such as peatland fires. Peatland fires emit very high amounts of greenhouse gas emissions and contribute greatly to the global ecosystem (Taufik et al., 2020).

*3.3.1 Ecological-social impacts of plantation land and e*cological-social impacts of other land

Further to the study conducted by (Taufik et al., 2020), the drought impact of converting peatlands to plantations is very high, as indicated by the 30% lower groundwater table on logged forest land and Acacia plantations compared to undisturbed natural forest. In discussing peatland ecosystems, it is necessary to consider the drainage system. The lowering of the water table can accelerate the drying of the root zone layer, which amplifies soil moisture stress. In the past decade, the frequency of droughts that have occurred due to peatland conversion is three times higher than that of pristine land. On the other hand, the presence of canalization can exacerbate drought twice as much, as it lowers the water table. Meanwhile, logging and conversion of land to plantations exacerbate it four times. On the other hand, according to (Mizuno et al., 2016), in developing countries with increasing populations, there is a strong socio-economic argument for exploiting natural resources to continue supporting people's lives and the country's economic development. So it cannot be denied, the dilemma between meeting economic needs with peatland conservation is still very strong and can influence both the increase of forest land and plantation land simultaneously. However, in the future there needs to be a firm decision from the government and other interested parties to maintain an increase in either forest land or plantation land.

In the map comparison picture above, it can be denied that the change of shrub land to swamp land/shrub swamp/secondary swamp forest significantly occurred from 2015 to 2020, which is clearly visible in the Central Katingan District area. According to (Murdiyarso et al., 2019), rewetting bushland or secondary swamp forest can reduce the total CO_2 flux in the area by up to 75%. Carbon stocks stored in shrub ecosystems are also lower, averaging around 949 Mg C ha^{-1} (Megagrams per hectare) compared to carbon stocks stored in secondary swamp forests, averaging around 1126 + 147 Mg C ha^{-1}. In general, total carbon emissions on shrub land surfaces are also higher than on shaded peat swamp forest land. From the map comparison above, it can be said that the shrub land seen in 2015 has gone through a process of water inundation, thus turning into swamp land to prevent high carbon emissions in the ecosystem.

Further to the map above, the area of secondary peat forest and peatland has increased by 55,339.07 ha, where it can be clearly seen in Mendawai sub-district that much of the open land has been covered by swampland. This is due to the restoration program being undertaken by both government agencies and PT Rimba Makmur Utama under the Katingan Mentaya Project (Hartono, 2020), which covers Mendawai and Katingan Kuala sub-districts and touches on East Kotawaringin district (Ramdhan & Siregar, 2018). Peatland enhancement and inundation can store more carbon stocks and prevent peatland ecosystems from drought and catastrophic fires during the dry season (Taufik et al., 2020).

4. Conclusion

The results of land cover/landscape change in Katingan District, both forest and peatland (consisting of primary dry forest, secondary dry forest, secondary mangrove, swamp, swamp scrub, and secondary swamp forest) and non-forest land, both increased in area, respectively by 26,532.61 ha and 4813.64 ha from 2015 to 2020. The ratio of forest and peatland to non-forest land remained the same from 2015 to 2020, at 4.18 and 4.2, respectively. Within the five-year period, there was only a 0.02 increase in land area, so there has not been a contrasting increase between the two lands.

The conditions of ecological and social impacts that are likely to occur in 2020 remain the same as the land cover conditions in 2015. This can be illustrated by the increased forest and peat land cover, such as secondary peat forest and peatland that increased and covered some of the previous open land, but some places experienced land changes to non-forest land, namely the expansion of agricultural land, plantations, and other uses from the previous five years. If the area of non-forest land continues to increase in the future, Katingan Regency is predicted to have a higher vulnerability to natural disasters such as droughts, fires and floods.

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Biographies of Author

Dilheim Biru, School of Environmental Science, Universitas Indonesia, Jakarta, 10430, Indonesia.

- Email: muhammad.diheim11@ui.ac.id
- ORCID: N/A
- Web of Science ResearcherID: N/A
- Scopus Author ID: N/A
- Homepage: N/A