Land Change Patterns for Predicting Sustainable Agriculture Development

[1]AGUS YADI ISMAIL, [2]SRI AYU ANDAYANI, [3]IVAN CHOVYAN, [4]ASEP WAHYUDIN

[1]Faculty of Forestry, Kuningan University Road Tjut Nyak Dhien Cijoho Kuningan Indonesia.
[2]Faculty of Agriculture, Universitas Majalengka Road K. H. Abdul Halim 103 Majalengka Indonesia.
[3]Faculty of Engineering, Universitas Islam Bandung, Indonesia
[4] Asep Wahyudi, Ciremai National Park (MCNP) in Kuningan Regency
Email: Agus.yadi@uniku.ac.id

Abstract. Land use must be planned and adjusted to the capabilities of the land itself. This study aims to analyze the pattern of land change over a period of 20 years in the Cimanuk Hulu watershed. The method employed is the confrontation between land-use patterns in 2000 and 2020. Landsat imagery through ERDAS Imagine 8.5 Software is used to analyze the classification of land use patterns from 2000 to 2020. Based on the analysis results, there has been an increase in land for settlements by 6.28 percent and water bodies by 2.35 percent. This is due to the construction of the Jatigede reservoir, while the allocation of rice fields decreased by 3.71 percent. For 20 years, there has been a change in land-use patterns by land conversion. This presents a challenge for the development in the Upper Cimanuk watershed area. Policymakers have a role in planning, developing, evaluating, and determining appropriate strategies in the process of sustainable agricultural development.

Keywords: land-use change, landsat imagery, upstream cimanuk.

Introduction

Regional development or natural resource management is related to land-use change as a phenomenon that must be considered, especially in developing countries. Irregular land-use changes will reduce the function of biological and ecosystem productivity on the land. Land degradation due to inappropriate agricultural activities will have an environmental and social impact. This should become a concern in policymaking concerning land use and agriculture (Rasul & Golam, 2009). This land-use change is an important phenomenon for every planner and regional policy maker (N Wijaya, 2015). Population growth affects changes in land use so that land-use planning must be done correctly (Widiatmaka, et al, 2015), Tejaningrum, et al, 2017.

In the United States, there are case studies that allow researchers and policymakers to focus on the relationship between agricultural land use, population change, agricultural sustainability, and the environment and society. This is because there has been a 35 percent decline in agricultural land since 1990 (Parton, 2003). Under these conditions, there is a need for an integrated assessment procedure to evaluate agricultural environmental policy strategies for sustainable agricultural development (Nijkamp, 2003). By looking at the decreasing agricultural diversity and threatening the sustainability of agriculture, it is necessary to have the concept of ecological, social, and economic dimensions (Tisdel, et al, 2019). The idea of sustainable land use continues to develop with the establishment of conditions for land-friendly and efficient land management (Moteva, et al, 2020).

Sustainable land use is a form of land management that maintains the natural fertility of the soil or it can be said that sustainable land use is more comprehensive than unsustainable land use. Sustainable land use includes not only the use of land for agricultural and forestry purposes, but also for settlements, industrial sites, roads, and other human activities. Rational land use planning is essential for this process (Wrachien, 2021). The world population is projected to reach around 10.9 billion in 2021. A population that continues to increase will also sustainably increase food production. However, there has been a significant decline in land and land degradation which become a challenge to redesign agricultural landscapes so that land use can be in accordance with the appropriate designation and be sustainable (Vimbayi, et al, 2021), (James, 2019). Food production in Indonesia depends on the island of Java which has the most fertile soil but is limited in a number of areas so that it is necessary to evaluate and analyze land availability. The analysis includes land evaluation with the integration of land structure, land capability, elevation, and land use/cover. Land availability needs to be analyzed by integrating the determination of forest area status and regional spatial planning patterns (Widiatmaka, et al, 2016).

Biodiversity conservation, protected area management, and sustainable development through strategies that take into account rural populations are current challenges in developing countries including Africa (Mucova et al, 2018). Sustainable agricultural land management can increase food production without destroying soil and water resources; it needs to be considered in developing countries because agricultural production is the fulfillment of food demand (Branca G, et al, 2013). Knowing that changes in land use are important for sustainable agriculture, then this study aims to analyze land changes over 20 years (2000 to 2020) and identify the main changes so that they are intended to predict and develop appropriate strategies for sustainable agriculture. This research was conducted in the area of the Upper Cimanuk River Basin (Garut Region, Sumedang).

Evaluation of existing land use and change is useful for the urban planner and natural resource management policymakers (Tahir, et al, 2013). Evaluation methods need to disclose sustainable land use and efficient land use as is the case in China (He Chenchen, et al, 2017). Non-degraded lands resources must be analyzed following land use capabilities and maintaining high land productivity (Widiatmaka, 2012). Such analysis is developed in this study (Bahagia, 2020).

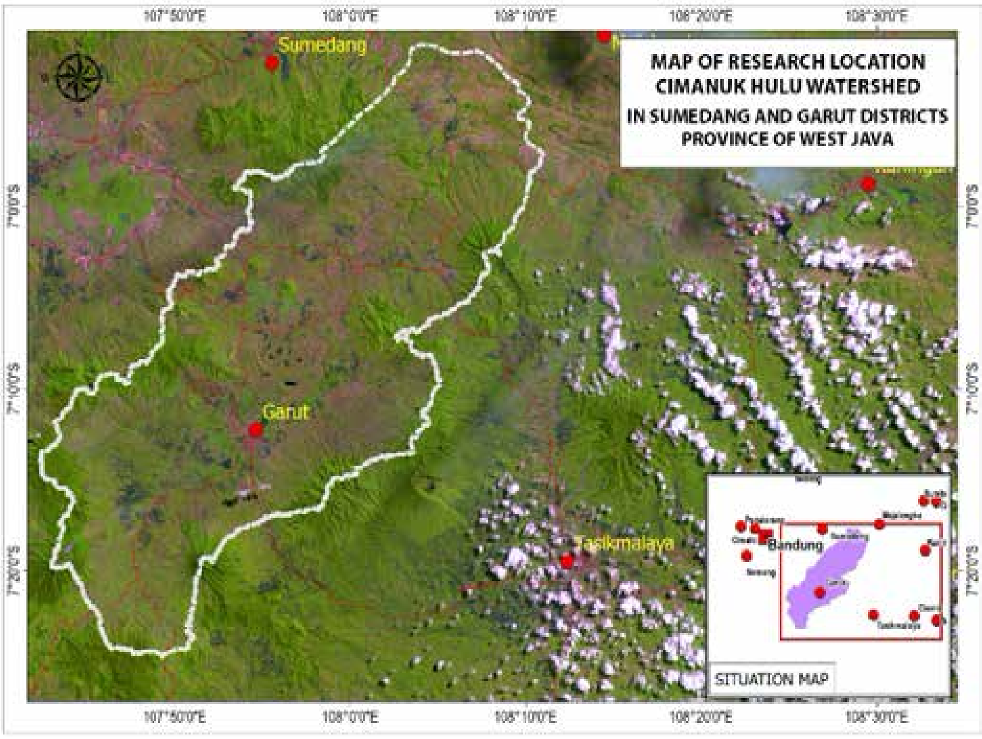

Figure 1. Location of Research

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Research Methodology

The location of the research was in the upstream Cimanuk river flow that includes two districts, namely Garut Regency and Sumedang Regency as the area of the study object. The data used are primary data and secondary data from different time periods, namely secondary data in 2000 and 2020, with the supporting tools and materials used of Arcview software and ArcGIS version 10.3 for spatial analysis. The research location is depicted in Figure 1.

The method used is satellite image interpretation, namely the activity of analyzing images from remote sensing technology to identify objects on the earth's surface by grouping these objects based on their appearance characteristics on satellite images.

The interpretation of satellite imagery produces a Land Cover Map (PL Map), which is a description of the appearance of the earth's surface that has been grouped into certain land cover classes according to the land cover classification structure.

Implementation Basis:

Technical Instructions for Interpreting Medium Resolution Satellite Imagery for National Land Cover Data Updates are issued by the Directorate for Inventory and Monitoring of Forest Resources No. Juknis 1/ PSDH/PLA.1/7/2020 dated July 6, 2020

Data Source:

Landsat 7 Enhanced Imagery Thematic Mapper Plus (ETM+) in 2000 and 2020. The tool used is a computer with the analysis program ArcGIS 10.3 software, Microsoft Word, and Exel 2000. Landsat7 ETM+ image data is processed using arcGIS software version 10.3 with the stages of interpreting Landsat imagery as follows: (1) Provision of Landsat 7ETM image data in 2000 and 2020; (2) Raster Processing by performing Composite Band using 3 original channels, namely bands 5, 4 and 3. This method is to identify rocks and landforms using relief approaches, flow patterns, and vegetation; (3) Radiometric and geometric corrections using the georeferencing tool in ArcGis 10.3 software by applying the image to image method which corrects an image with other images that have been corrected by comparing the appearance of the image to be corrected against the reference image; (4) identification of research area boundaries; (5) Landsat Image interpretation by using the on-screen digitization method carried out directly on the computer screen after the image as the data source has been processed to provide an optimal visual appearance that shows the differences between objects. Furthermore, Landsat image interpretation is carried out, namely, the process of identifying certain objects or features based on elements of interpretation, referring to the key to Land Cover Classification SNI 7645:2010; (6) Land Use Patterns in 2000 and 2020 by grouping into 11 land cover classes; (7) Identification of Changes, which can be seen in Figure 2.

Results and Discussion

Land Use in 2000 and 2020 in the upstream Cimanuk Area

Based on the results of the Landsat TM 2000 and 2020 image classification process, the spatial configuration and classification of land use patterns in the upstream Cimanuk river basin includes two districts: Garut and Sumedang. Both districts are grouped into 11 patterns of land change, namely primary dryland agricultural areas, secondary dry land, plantation forests, settlements, dryland agriculture, dry land mixed with shrubs, rice fields, shrubs, open land, and bodies of water.

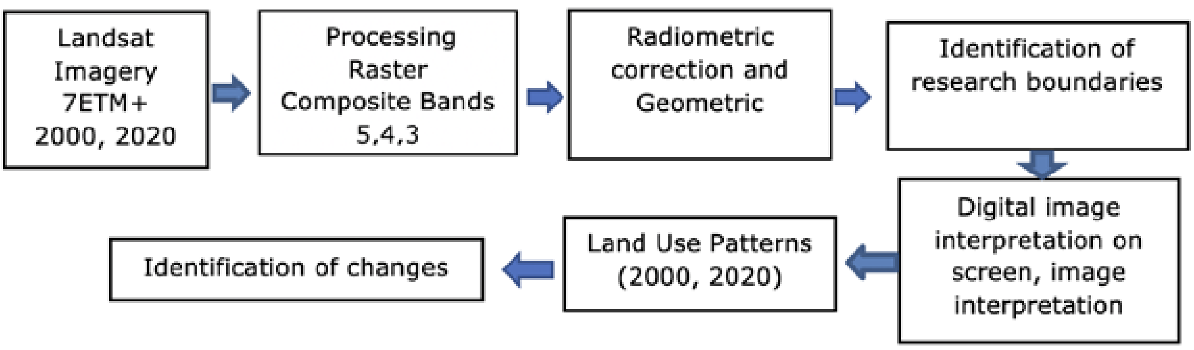

Figure 2. Research Line of Thought

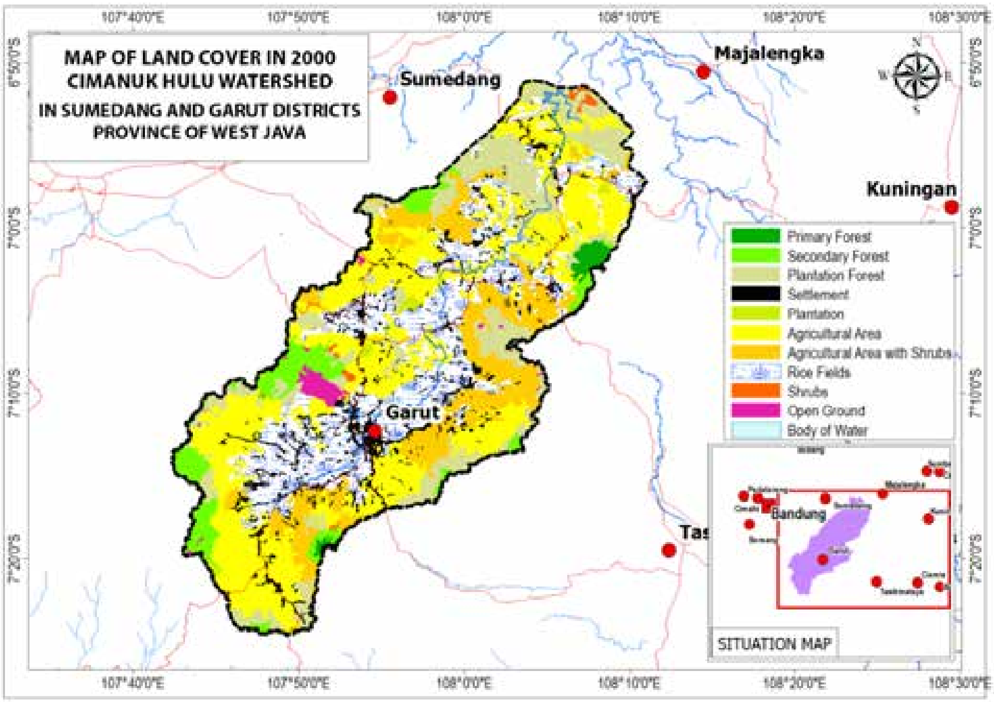

Figure 3. The Results of 2000 Landsat Imagery Calculations

Patterns of Land Use and Changes in the upstream Cimanuk River

Pattern of land change in in 2000 and 2020 underwent very significant changes, especially changes based on the interpretation of Landsat imagery on the basis of determining the use of color channels (Band). It can be seen that in 2000, the land use in Cimanuk was still dominated by dry agriculture (32.93%), followed by rice fields (22.72%), plantation forests (15.43%), and agriculture on dry land mixed with shrubs (13.25%) percent. A description of land use in 2000 can be seen in Figure 3.

The figure 3 explains that the land use for dry land and rice field agriculture in 2000 was very dominant, while the land use pattern in 2020 was still dominated by dry land and rice fields in upstream Cimanuk. However, based on image interpretation in 2020, there was a significant decline in land use, especially in the percentage of land use from 2000 to 2020, where plantations decreased by 1.09 percent, dry agriculture by 2.91 percent, even rice fields experienced a bigger decline of 3.71 percent. The picture of changes in land use in 2000 can be seen in Figure 4 and Table 1.

Judging from the pattern of land changes in each type of use in the area around Cimanuk River Basin, it is predicted that it will experience a continuous decline for plantation forest areas, mixed vegetation, agriculture, and rice fields as shown in Table 1, which is due to the greater human need for land. Changes in land-use patterns can also result in various disasters in the upstream and downstream areas of Cimanuk River, such as floods, drought, and even erosion. From the results of field observations in the area around Cimanuk upstream, several factors led to a pattern of land change including (1) population growth which continued to increase that had an impact on the increased demand for residential land, (2) the biophysical conditions of the upstream Cimanuk River Watershed were converted to agricultural land and cultivation such as for horticulture in the Mount Cikurai area, Papandayan, (3) community farming patterns that continue to utilize Watershed conservation areas without applying the principle of soil and water conservation, and (4) the community continues to do a lot of horticultural activities in the watershed area of Garut Regency. There is also a relationship between climatic conditions and land-use change in Jakarta, Indonesia (Tursilowati, et al, 2012), land-use change and temperature change (Hidayati, et al, 2014), and land suitability in determining conservation areas (Wijaya, 2004).

The calculation results of Landsat imagery showed that during a period of 20 years there was a change in land use from the undeveloped land to build up the land. These changes and improvements need to be

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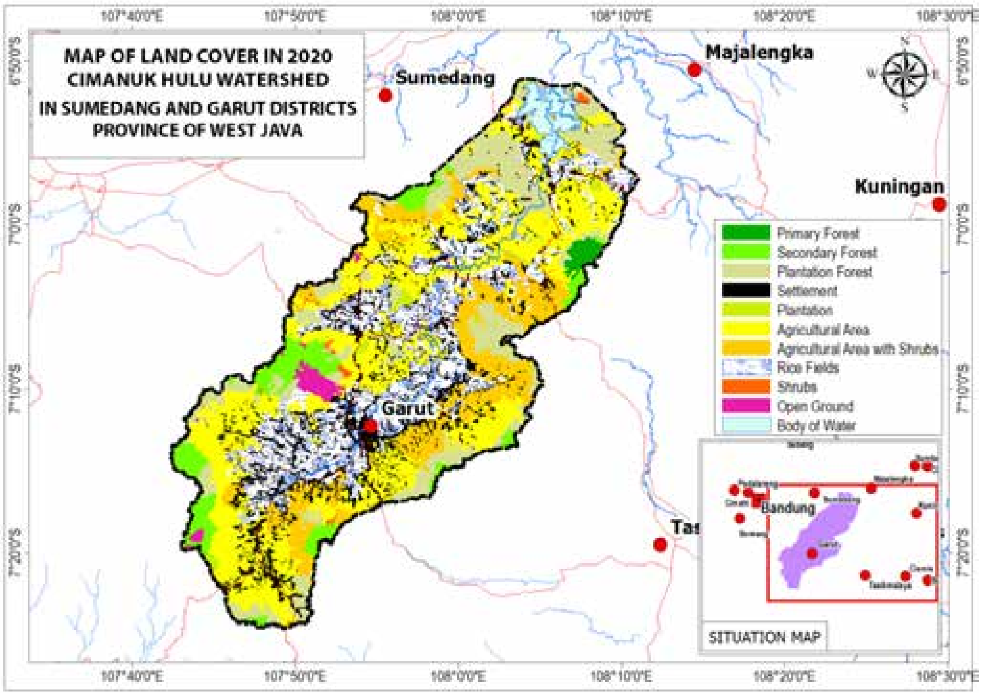

Figure 4. The Results of 2020 Landsat Imagery Calculations

evaluated for future agricultural development so that people do not lose their livelihoods as farmers due to changes in land-use patterns in the upstream Cimanuk area. Clearing new land for sustainable agriculture and rice fields as perennial land or land reform can be used as an alternative to sustainable agricultural development.

Conclusion

The results of the study based on the analysis of patterns of land-use change over a period of 20 years from 2000 to 2020 showed there were changes. There has been an increase in land for settlement by 6.28 percent and water bodies by 2.35 percent due to the construction of the Jatigede

Table 1
Classification of Land Use in the Upstream Cimanuk River Flow Area

Number	Land Closure	Year 2000 (Hectare)	%	Year 2020 (Hectare)	%	Changes
1	Secondary Dry land Agriculture	1,455.32	0.99	1,177.11	0.80	(278.21)
2	Primary Dry land Agriculture	8,923.86	6.07	9,037.61	6.15	113.74
3	Forest Plantation	22,680.35	15.43	21,077.59	14.34	(1,602.76)
4	Settlements	9,434.93	6.42	18,672.88	12.70	9,237.95
5	Plantation	862.30	0.59	950.00	0.65	87.70
6	Dry Agriculture	48,407.62	32.93	44,133.23	30.02	(4,274.39)
7	Dry land Agriculture mixed with shrub	19,479.83	13.25	18,290.16	12.44	(1,189.67)
8	fields	33,398.89	22.72	27,953.01	19.01	(5,445.88)
9	Open land	671.98	0.46	463.07	0.32	(208.91)
10	Water body	1,530.90	1.04	1,639.28	1.12	108.38
11	amount	160.74	0.11	3,612.79	2.46	3,452.05

Source :

reservoir, while the allocation of rice fields decreased by 3.71 percent as well as a decrease in agricultural land and forests. The change in land use presents a challenge for the development in the Upper Cimanuk watershed area. Things that need to be considered in this condition are an evaluation of the concept of sustainable agricultural development as well as a balance between ecology and economy towards land cover classification as the basis for the pattern of land-use change.

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