

THE DYNAMICS OF LAND COVER CHANGE AND CAUSAL FACTORS IN THE KURANJI WATERSHED

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ABSTRACT: Landcover changes (LCC) are one indicator of an increase in population in a watershed area that demands the provision of housing locations, road infrastructure, and productive land to meet the needs of life. LCC can positively impact the form of increased land use values and incomes, while also negative impacts in the form of erosion, landslides, and floods. The watershed area should have a balance in its development. This research is important as a first step in overcoming changes in land cover that can threaten the sustainability and sustainability of the Kuranji watershed. The aim of the study is to reveal the LCC from 1985 to 2018 and its causal factors in the Kuranji watershed. The methodology used is descriptive qualitative with 60 respondents. Data were obtained by interviewing respondents. Respondents are those having agricultural land and working in the agricultural sector and this research was carried out in 2019. The results showed an increase in the type of land cover of settlements and mixed gardens, while forests, rice fields and shrubs have decreased. The main factor influencing changes in land cover is economical (59%), followed by social factors (25%) and political factors (16%). It was also found that local wisdom of the Minangkabau culture was able to reduce LCC. In Minangkabau, the land owned by the community, in general, is a legacy from generation to generation that cannot be sold without significant reasons.

Keywords: LCC, ArcGIS, Descriptive qualitative

1. INTRODUCTION

Land Cover Change (LCC) is a major issue in the watershed area. This change becomes very dangerous if it occurs in the upstream watershed which is a protected area and conservation area. LCC have an influence on the carrying capacity of watershed areas if done on a large scale. This can cause landslides, floods, and other hydrogeological disasters.

LCC in the watershed area occurs from time to time. The increase of LCC is in line with the increase of the population. The higher the population, the land needs are also increasing. The increasing need for land must be accompanied by soil and water conservation techniques so that the impact caused by changes in land cover can be minimized.

One of the watersheds undergoing land cover change is the Kuranji watershed. This watershed has an area of 22,469.55 hectare located in Padang City. Statistical data show there has been an increase in population in the Kuranji watershed, namely in the Districts of Kuranji, Pauh and Koto Tangah in the past five years. The increase was 60,441 people, with a population growth rate of 2.28 - 2.83% [1]. The high rate of population growth triggers land conversion that aims to meet the needs of life. Examples of these changes are

forest area into agriculture, and agricultural area into a developed area.

The change in the Kuranji watershed is very dynamic because it is in an urban area. LCC in the Kuranji watershed is also triggered by the growth of tertiary education areas. The development of this education area has triggered the community to provide infrastructure to support educational activities such as student boarding houses, food stalls, photocopy stalls and others. This makes the area around the tertiary education a satellite city.

LCC in the Kuranji watershed have increased quite rapidly in the past 10 years. This change is due to the occurrence of a large earthquake in Padang City on 30 September, 2009, having the potential for a tsunami. Since the earthquake, some people who lived on the coast have moved to the central Kuranji watershed, which is a tsunami safe zone. The move of coastal communities in the central part of the Kuranji watershed was also encouraged by the prediction of the Mentawai Megathrust earthquake accompanied by a tsunami.

LCC in the Kuranji watershed are very dangerous, especially in the upper and middle watersheds. This is because the Kuranji watershed has a steep topography of 54.66% of the watershed area. Judging from the shape of the watershed, the Kuranji watershed has a shape that extends near the moon in the upper reaches. This form explains

that the Kuranji watershed has a great potential for flooding if vegetation cover is reduced and does not function as a soil protector. More details about the slope of the Kuranji watershed can be seen in Fig. 1.

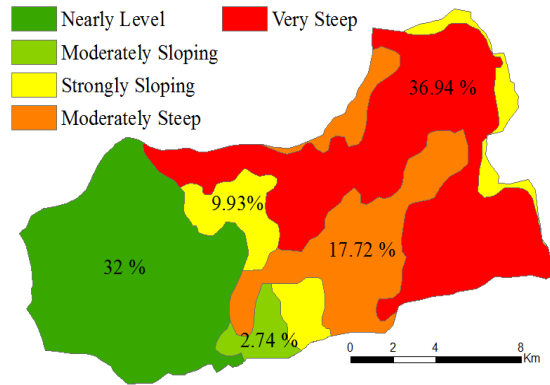


Fig. 1 Slope conditions in the Kuranji Watershed

The objectives of the research are to reveal into what extent the LCC has been taking place in Kuranji watershed in the last 33 years (1985-2018) and to discover the factors causing changes in land cover.

2. RESEARCH SIGNIFICANCE

This research has revealed that the changes of land cover in the Kuranji watershed mostly influenced by economic factors. In order to meet their basic needs, community changed the function of green area such forest and agricultural land into built area. As a result, the downstream area becomes more vulnerable to flood. The local wisdom of Minangkabau culture has been proven to reduce the acceleration of land cover changes. Nevertheless, government policy in granting strict permits for land cover changes are also highly needed.

3. MATERIALS AND METHOD

3.1 Materials

This research was conducted at the Kuranji watershed in Padang City, West Sumatra, Indonesia. It has a maximum height of 1860 meters above sea level with annual rainfall of more than 5,054 mm. Based on geographical position, the Kuranji watershed is located between 100°21'18,84" E - 100°33'52,87" E and 0°47'23,36" S - 0°56'13,71" S. Determination of LCC was by using a 1985 topographic map with a scale of 1: 50,000 and SAS Planet (Arc-GIS Imagery) satellite imagery in 2018 with a spatial resolution of 20x20 meters. The tools used are GPS and

ArcGIS 10.6. Information gathering factors that cause changes in land cover was by open interview techniques.

3.2 Method

The methodology used in determining land cover change is to perform interpretation and delineation analysis on each map year using ArcGIS 10.6. Then, an area value analysis is performed on the attribute table, so that, every year, the map will contain the value of each land cover and the factors that support changes in land cover determined using descriptive qualitative analysis methods.

This research was conducted from July 2019 to November 2019. Data were collected through interviews with respondents with a purposive sampling technique. Requirements to be a respondent are people who have agricultural land and people who work in the agricultural sector. The respondent sampling locations are people who live in the middle and upper Kuranji watersheds with 60 respondents.

In technical data collection, the researcher asks questions to the respondent related to the purpose of the study and the respondent answers them. Data needed from respondents are divided into three factors. 1). Economic factors, including community income, land value, development of education centers. 2). Social factors, including population growth, land ownership, environmental knowledge, agricultural land needs. 3). Political factors, including the high cost of living and weak law enforcement.

After obtaining research data, tabulation of the data is based on economic, social and political factors to obtain a percentage value. Then, a qualitative descriptive analysis is performed.

4. RESULT AND DISCUSSION

4.1 Land Cover in 1985

Land cover in the Kuranji watershed in 1985 was obtained by conducting spatial analysis using a topographic map in 1985. Land cover is grouped into five types. The land cover is classified into forests with an area of 13,242.54 hectare, settlements of 1,507.54 hectare, paddy fields 4,131.67 hectare, shrubs 2,064.41 hectare and mixed gardens 1,523.39 hectare. The complete land cover of the Kuranji watershed in 1985 can be seen in Fig. 2.

4.2 Land Cover in 2018

Based on the results of the interpretation of satellite imagery in 2018, land cover in the Kuranji

watershed is grouped into five types.

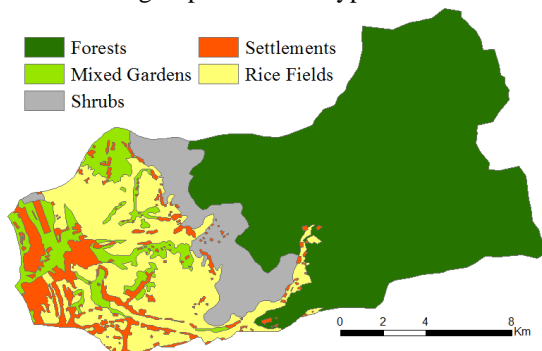


Fig. 2 Type of Land Cover 1985 in Kuranji Watershed

The land cover is a forest with an area of 12,114.12 hectare, settlement 4,084.62 hectare, rice fields 2,935.98 hectare, shrubs 747.61 hectare and mixed gardens 2,587.22 hectare. The land cover of the Kuranji watershed in 2018 can be seen in Fig. 3.

LCC in the Kuranji watershed that occurred in 1985 to 2018 were dominated by the reduction of forest area by 1,128.42 hectare. Forest areas turned into mixed gardens and shrubs. Paddy fields also experienced a reduction of 1,195.69 hectare. Most of the changes in rice fields were into settlements. Shrubs also experienced a reduction of 1,316.8 hectare, turning into mixed gardens, rice fields and settlements. Reducing forest areas or vegetation areas to other areas will have an impact on the environment, including erosion, flooding and reduced groundwater supplies.

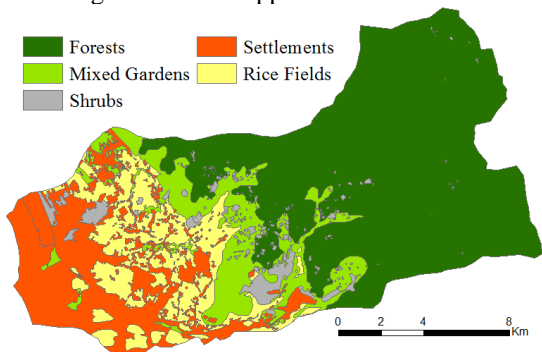


Fig. 3 Type of land cover in 2018 in Kuranji Watershed

The impact caused by the reduction of forest area or vegetation area has also been conveyed by several experts. According to [2], the decrease in vegetation cover in the watershed area by 91% caused erosion of 7.2 to 7.7 tons / hectare / year. According to [3], an increase in forest area can increase the quality and quantity of water, while [4] added that forest areas were better able to increase water fill from ground level to aquifers compared to agricultural land.

Not only LCC, high and intensive agricultural

activities in land management in the Kuranji watershed can reduce environmental quality. This was stated by [5] that intensively cultivated agricultural and horticultural land resulted in soil degradation. Based on the opinion of the experts above, it can be concluded that maintaining forest cover and vegetation cover can reduce erosion, surface runoff and flooding.

The fact that has occurred in the Kuranji watershed is that forest areas that are in protected and conservation areas have begun to decrease and settlement areas are increasing. Reduction of forest area results in low infiltration and high surface runoff resulting in flooding. [6] added that the Kuranji watershed often results in flooding due to low infiltration while [7] reported that changes in land cover from natural land use to anthropogenic have increased surface water. This has a big impact when accompanied by very high rainfall intensity. [8] stated that the reduction in vegetation had an impact on the increase in flood inundation areas.

In addition to reducing land cover, several types of land cover in the Kuranji watershed have also increased. The increase was experienced by mixed garden land cover of 1,063.83 hectare and settlements of 2,577.08 hectare. The high change in land cover is due to the high rate of population growth. Changes in land cover in the Kuranji watershed have increased since 1985 and in 2009 after the earthquake that hit Padang City. More details on differences in LCC from 1985 - 2018 can be seen in Fig. 4.

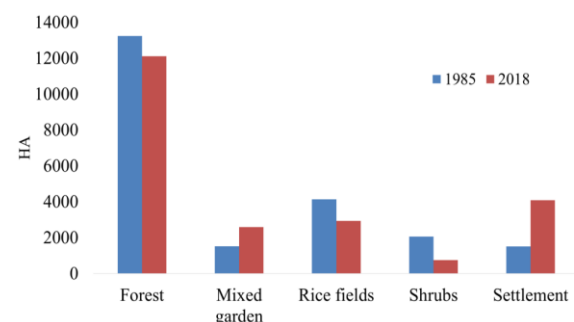


Fig. 4 LCC between 1985 and 2018 in Kuranji Watershed

LCC to land that does or does not lack vegetation has an impact on the amount of erosion, surface runoff and flooding. [9] mentioned that changes in forest cover result in critical land and have an impact on landslides, especially on steep slopes and exceed 40%. [10] One such impact is caused by the loss of vegetation (plant roots) in protecting the soil from the danger of soil erosion. It was also added by [11] that changes in land use into built up areas would have an impact on changes in flow characteristics, flooding in the rainy season, decreasing river discharge and

drought in the dry season.

The topography of the Kuranji watershed in the middle and upstream is quite steep. This area has changed forest cover through illegal logging. This type of forest land covers turns into shrubs, mixed gardens and agricultural crops.

This area is a protected forest and conservation area and the protection of this area aims to maintain the quality of the watershed, such as physical land, water management and biodiversity. For more details on changes in types of forest land cover due to illegal logging in protected and conservation areas (Fig. 5).



Fig. 5 Illegal logging in upstream watershed

Fig. 6 explains that land cover conversion converts forests into shrubs and agricultural crops. Protected forests have changed by 118.17 hectare (4.1%) and conservation areas by 16.74 hectare (0.18%). In other areas of use, there was a change in land cover of mixed estate gardens to become shrubs and agricultural crops by 63.1 hectare (0.6%).

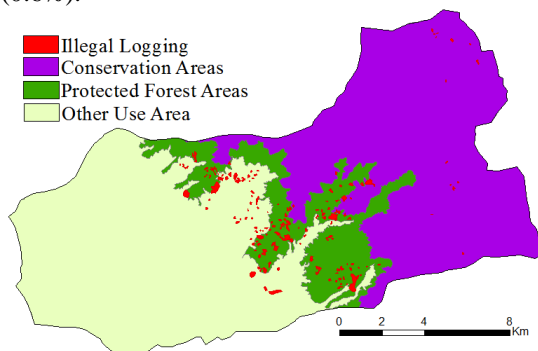


Fig. 6 Illegal logging in protected forests and conservation areas

LCC have a major impact on soil erosion, surface runoff and flooding. This change becomes very dangerous if it occurs in steep sloped areas such as the Kuranji watershed. The steeper a slope, the faster the surface flow and the greater potential to wash away soil particles. It was also stated by [12] that the slope factor has a great influence on the high surface runoff and causes flooding.

Previous researchers also conveyed the impact caused by changes in land cover. [13] stated that changes in forest land cover to build up land and agriculture can increase flood discharge.

4.3 The Cause of LCC in the Kuranji Watershed

The condition of the Kuranji watershed area does have its own attraction in the occurrence of changes in land cover. This is because the Kuranji watershed is the largest in Padang City, where parts of the region have economic centers such as the area of higher education. The growth of economic centers will lead to the conversion of land into developed areas. On a large scale, it will disrupt the sustainability of the watershed. It was stated by [14] that the change of land cover into a residential area made the Kuranji watershed vulnerable to flooding. This is caused by damage to the physical properties of the soil and has an impact on reducing infiltration.

Based on the analysis of satellite imagery in 2018, changes in the type of land cover from forest vegetation to mixed plantations and shrubs continue to occur and threaten the sustainability of the upstream watershed. The change in land cover is in the middle Kuranji watershed and toward the upstream watershed. Generally located in protected areas and conservation areas.

The LCC explains that there is human activity in the area that must be protected and the ecosystems conserved. Thus, it is important to know what factors are driving the community to make changes in land cover. More clearly the cause of changes in land cover in the Kuranji watershed can be seen in Fig. 7. The dominant factor causing changes in land cover in the Kuranji watershed is economic with a value of 59%. These economic factors explain that the level of income and the number of family dependents encourage the community to be even more active in meeting their daily needs. The method adopted by the community is to change the forest land cover into mixed gardens and paddy fields to settlements.

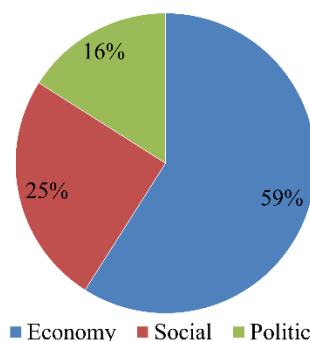


Fig. 7 Causative factor LCC in Kuranji Watershed

The high value of land around the tertiary education area encourages people to sell land and increase land use value. So what was once planted agricultural land is converted into built land such as boarding houses, food stalls and shops. All

these changes are intended for students and the local community in supporting education and other activities. The same thing was said by [15-17] that changes in land cover will be faster if an area changes from an agrarian area to an area that develops an economy in the service sector.

Previous researchers have also expressed their opinions about the factors that cause changes in land cover. As stated by [18], changes in land cover are strongly influenced by socioeconomic factors. [19] also stressed that the LCC was driven by economic development and the development of educational areas. [20] and [21] added that changes in land cover and increased built up land were influenced by economic factors, as apparent in the Kuranji watershed. This can be explained as that the Kuranji watershed's strategic location in the economic field, means it can increase the built area quickly.

The next factor affecting changes in land cover is the community social factor of 25%. The low level of income of the community as farmers who live in the middle part of the Kuranji watershed has led the community to begin to utilize the upstream watershed area. Small land tenure makes people change forest land cover in the upstream watershed with the goal is to increase the area of agricultural land and increase income.

Part of the forest cover is converted into mixed gardens with durian (*durio zibethinus*), mangosteen (*garcinia mangostana*), rambutan (*nephelium lappaceum*), jengkol (*archidendron pauciflorum*), petai (*parkia speciosa*), cacao (*theobroma cacao*), pohon sirih (*areca catechu*), and pohon jati (*Tectona grandis*). In some places that are easily accessible, people plant serai (*cymbopogon citratus*), and lime musk (*lat. citrus amblycarpa*).

In the Kuranji watershed, the middle part of the paddy field is converted into a settlement. Shrubs become mixed settlements and gardens. Changes in land cover are also caused by the high rate of population growth in the Kuranji watershed, which ranges from 2.28% to 2.83%. In line with the opinion above, [22] added that the increase in agricultural land and population growth most determine the change in land cover. This explains that there is a high dependence on forest products in increasing community income.

The Kuranji watershed community is aware that changing forest cover can cause catastrophic floods and landslides. However, LCC are still being made with the aim that economic needs continue to be met. As long as the economic needs have not been met, the change in forest land cover will continue to occur. It was also stated by [23] that the change in land cover is strongly influenced by socioeconomic aspects.

High population growth in the Kuranji

watershed also supports accelerating land cover changes. The change is related to the needs of the community for a place to live and to conduct economic activities. [24] states that an increase in population also has an impact on increasing changes in land cover.

An interesting factor of community attitudes toward changes in land cover is also influenced by Minangkabau culture. This culture explains that people who own customary land can only use it and it cannot be traded. Utilization is for agricultural land, community plantations, mixed gardens and a small portion for shelter. The strong culture of Minangkabau adopted by the community means changes in land cover are not so great. [25] explained that local culture can reduce access to forest areas. This has an impact on the reduced harvesting of forest wood, which causes changes in land cover.

Political factors also affect changes in land cover of the Kuranji watershed with a value of 16%. The high cost of living resulting from government policies drives people to try to increase income. One method is the use of forest areas for agriculture. [26] explained that government policies, population growth and socioeconomic impact had a large influence on changes in land cover. [27] also stated that national and international policies have the potential for changes in land cover in agriculture. Weak law enforcement also makes people uncontrollable in making changes to land cover.

5. CONCLUSION

LCC in the Kuranji watershed from 1985-2018 are very high. The biggest change was in residential land cover with an increase of 2,577.08 hectare (63.1%). Mixed gardens also increased by 1,063.83 hectare (41.12%). Reduction of forest land cover was by 1,128.42 hectare (8.52%), rice fields by 1,195.69 hectare (28.94%) and shrubs by 1,316.8 hectare (63.78%). LCC have occurred in protected and conservation areas. This area is a forest area that should not be disturbed. Disruption to this area is due to an increase in population and the necessities of people's lives. The factors causing LCC are influenced by economic (59%), social (25%) and political (16%) factors. Economic factors are influenced by low community income, the number of family dependents and high land values. Social factors are influenced by population growth, agricultural land needs, small land tenure and community knowledge and attitudes towards the environment. Political factors are influenced by the high cost of living and weak law enforcement. One important finding in this research is that the local wisdom of the Minangkabau culture adopted by the

community can reduce land cover changes.

6. ACKNOWLEDGMENTS

We want to express our sincere gratitude to the University of Andalas for the 2020 Research Grant.

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