Application of remote sensing and GIS for temporal dynamics of land use and land cover changes in 2013-2018 for watershed protection

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Abstract. In the past decade, various environmental problems have emerged related to land resources. The facts show that the rate of degradation of land resources and the decline in environmental quality in Indonesia have recently increased and have not shown signs of decline. The degradation of land resources and environmental quality need to be taken seriously so that increasingly serious environmental problems can be avoided. The purpose of this study is to determine the temporal dynamics of watershed land cover in Sinjai Regency and analysed the effect of land cover changing on the in protection function index of the Sinjai watershed in the year 2013 to 2018. Research was using quantitative research. This research is closely related to the enumerative induction process (induction based on calculations). The main causes of landslides in Sinjai Regency consist of rainfall, slope, and land cover. Part of the level of potential landslides based on rainfall is divided into low classes with a range of 2000-2500 mm rainfall, areas scattered in Sinjai Bulupoddo Regency, North Sinjai, parts of North Central Sinjai Regency and Northeast Sinjai District. While the area is located in the class of landslide potential, namely in the range of rainfall 2500 mm - 3000 mm, the potential for the spread of northern Sinjai, West Sinjai, Central Sinjai Regency, Sinjai District, East, and South Sinjai.

1. Introduction

The Land is one of the most important resources and is very much needed to sustain human life and other living things. The problem of land resources has a very broad scope. These problems include land degradation and damage, conversion of productive agricultural land to non-agricultural use, disparity and fragmentation of land tenure or ownership [1]. One of the most vulnerable issues related to land resources is land degradation. Land degradation is a process of decreasing land productivity, both temporary and permanent [2]. In the past decade, various environmental problems have arisen related to land resources. Watershed is an ecosystem. The activity of each component of the ecosystem always affects the other components of the ecosystem. As long as the interrelationships between the components of the ecosystem are in a balanced state, during the same time the ecosystem is in a stable condition. Conversely, if the interrelationships between environmental components are disturbed, and ecological disturbance will occur. Natural resource utilization activities carried out in the upstream area will have an impact on the middle and downstream watershed in the form of, among others,
decreasing reservoir capacity, river silting, which ultimately increases the risk of flooding, and others. The function of a watershed is a joint function carried out by all the factors present in that watershed, namely vegetation, terrain (topography), soil, water, and human. Activities that occur in the watershed will affect the watershed ecosystem. Changes in land use, especially in upstream areas, can have an impact on downstream areas between changes in water flow fluctuations and sediment content and other materials. Land use is dynamic, so it will always change from time to time. Changes in land cover is a state of land due to human activities that are experiencing conditions.

Change at different times. The dynamics of changes in land cover in the watershed in Sinjai Hulu Regency need to be monitored and controlled so that the protection function index can be maintained, which in turn will affect the quality of the watershed in the Upper Sinjai District as an ecosystem that has the main function as a water catchment area and the protection function of all parts DAS. Therefore, a temporal study of land cover change and its effect on the protected function index is important.

Land use change and has a very strong influence on the continuity and level of watershed stability and is evenly distributed in many areas this is in accordance with the results of research using satellite imagery and GIS data referring to land cover changes based on time [3], with the Bandung Regency research object, very rapid development, especially in the northern part of the research area, namely in the District of Serpong, much developed as a residential area. The existence of increasingly limited land in Serpong Subdistrict led to the expansion of residential areas to Cisauk Subdistrict where land availability was still quite extensive. In the last 3 years, the development of settlements in this region has occurred rapidly so that land use is very dynamic, especially the change of non-developed land into built-up land. This condition shows that land availability is decreasing, along with the high settlement needs as a result of increasing population. In land use change there is a transition process of land change, ie from agricultural land not directly to built up land but to grass / vacant land or shrubs.

Other studies using satellite imagery data and GIS conducted [4]. In this study, the rainfall analysis uses the maximum annual average daily rainfall data, an area in the Bengawan Solo watershed that has a high average rainfall spread in the Surakarta region which is the upstream area of the Bengawan Solo watershed, which includes rain station posts in Cepogo, Boyolali, Sumberlawang, Polanharjo, Mojo. From the analysis of rainfall which has a value of more than 100 mm hour-1, the distribution is only in the Surakarta, Madiun and Rembang regions. While, in the downstream areas the value of rainfall is not so great. From this map, it can be seen that the rain which is more than 120 mm in day -1 is in the Surakarta region which is upstream from the Solo River Basin. While the Bojonegoro region itself is classified as having a uniform rainfall with a value that is not so large. Based on these studies it can be concluded that the application of satellite imagery data can provide information about the rate of land change and the rate of climate that affects the watershed.

In line with research conducted [5], based on the DEM-SRTM (Digital Elevation Model-Shuttle Radar Topographic Misson) image in 2000 as in Figure 2, it can be analyzed that from the DEM-SRTM image in 2000 in West Java, especially Tenjolaya Village, Bandung Regency, the location varies between the lowlands in the south and increasingly to the north is a plateau, which has an altitude between 0 to 1000 m above sea level. With the application of image data we can see the appearance of the earth and the vegetation above it without having to make a direct visit to the field. Based on DEM image data, the researcher obtained information about slope height and slope level classification as the research conducted [6] where areas with high landslide potential are in areas with steep slopes with slopes of between 40% -70%, with landforms generally in the form of mountains and hills incised in moderate to severe.

Research conducted [7], Based on the accuracy test using the Confusion Matrix Calculation, it is known that the level of accuracy of interpretation of panchromatic black and white aerial photographs of 1: 8900 scale in 1996 is 85% and for 1: 5400 scale color Quickbird images in 2008 amounted to 90.02%. In accordance with Anderson's opinion in Lo (1996) that an interpretation result can be used for analysis if the level of accuracy reaches a minimum of 85%, this means it is in accordance with the guidelines. Accuracy of interpretation results on images
In this study a categorical accuracy test was also carried out to determine the level of accuracy of each land use category. Because in general, misinterpretation occurs in land use in one category. The results of the land use accuracy test for aerial photography are as follows; settlements (97.36%), agricultural land (80%), transportation and industrial land (100%), recreation and sports land are 92.85, places for worship are 100% and other land 90.90%. Meanwhile for Quickbird imagery, settlements are 97.50%, agricultural land 85%, land transportation and industry (100% each), recreation and sports 95.33%, land for places of worship 100%, and other land 90.87%.

2. Materials and methods
This research is a spatial-based research, the material that will be used in this study are maps of the research area, while the materials needed are as follows: Repprot map, administrative map, rainfall map, soil type map, DAS map, soil type map, slope maps, existing land cover maps, raster data include, RBI maps, SRTM data, Landsat TM 8 image data in 2014, Landsat 2018 image data and 2019 spot image data.

Research to produce a model of monitoring the rate of change in land use with the following stages: a. mapping, at this stage will be mapping based on data from several years about land cover and land use at the study site, identifying the rate of change in land use (agriculture, plantation, forestry, fisheries and animal husbandry involved in this activity are the lead researchers and members as well as students included b) identifying risk events from the rate of change in land use and land cover over a period of several years

Inventory of partnerships that can provide solutions to problems faced by research sites (those involved in this activity are the lead researcher and the members and students involved), d. conduct an analysis of risk events that require immediate handling based on findings from an inventory of cases in the field (those involved in this activity are) e. analyze various efforts that have been taken by environmentalists to save the watershed conditions (avoid, transfer, mitigate, keep or a combination of these possibilities) (involved are the lead researchers and members and students involved) f. formulate risk mitigation strategies for problems encountered in the field

3. Results and discussion
The study began by interpreting land cover using satellite imagery data for Landsat TM types with different types of years, namely 2014 and 2019 data (figure 1). By using RGB composites with the same band channels, 1,2,3 and 4,3,2 as shown in figure 1.

![Figure 1. Display of Landsat imagery in 2014 and 2019](image-url)
The image data in figure 1 has not yet been classified as land use. The image is made in the same composite, namely 1,2, 3 and 4,3,2 from this image, the study can identify the type of land use based on the TN value of each observation point.

3.1. Land use

The land use map functions as a center for land use information in the area to be mapped so that it can know areas that may be affected by landslides. Areas that can be affected by landslides can be residential areas, protected forest areas, and so forth. This map can also be a guideline for further analysis to determine the location of an evacuation if a landslide occurs in a residential area. For land use in Sinjai Regency, we can see in figure 2.

![Map of land use in Sinjai Regency](image)

**Figure 2.** Map of land use in Sinjai Regency

Mixed dry agricultural land is the most extensive land use in Sinjai District. This land use occupies 78% of the total land use of Sinjai Regency. The highest proportion of mixed dry land is found in the districts of South Sinjai, Central Sinjai and Tellulimpo. Rice fields occupy 13% of the total land use. Rice fields are scattered throughout the district. In Sinjai District, part of the dry land farming area is abandoned so that many bushes are overgrown. Tegal is often found in the District of West Sinjai. Shrubs are often found in the District of West Sinjai. Shrubs are dryland agricultural areas that have not been cultivated for a long time so that they are overgrown with shrubs, or often also found shrubs left to grow together with fruit or plantation crops.

The use of shrub land occupies about 2.33% of the entire area of Sinjai Regency. Shrubs / shrubs generally take the form of vegetation that grows in areas of former cultivation and is allowed to grow freely. Some shrubs / shrubs occupy former reforestation areas that have caught fire. Shrubs / shrubs are often found in areas that include Sinjai District, the area of land use is 1,949 ha. Secondary forests occupy an area of around 6.21% of the total area of Sinjai Regency. Secondary forests are scattered locally almost throughout the area of Sinjai Regency, especially in the Districts of West Sinjai, South Sinjai, Central Sinjai and Sinjai Borong. Mangrove forests can be found in the Districts of East Sinjai and North Sinjai, this land use area is around 0.06% of the total area of Sinjai Regency. Settlements are scattered along the main road. Settlements are not well identified in the ETM + Landsat image due to the relatively narrow area of built land.
3.2. Rainfall
Rainfall is also influential and is a basic map that is owned because the rainfall in each location is also different. In addition, rain also affects landslides so that if the type of soil with the highest score and with the highest rainfall score as well, it can be estimated that the area is prone to landslides.

In Sinjai district the rainfall is in the range of 2000 mm to 4000 mm which is in several districts and each district has a different rainfall value as well. The level of landslide potential distribution based on rainfall is divided into low classes with a range of rainfall in the values of 2000-2500, scattered areas in the Sinjai Bulupoddo District, North Sinjai, parts of the North Central Sinjai District and the North Eastern Sinjai District. While the area that is in the category of moderate landslide potential that is in the range of rainfall 2,500 mm – 3,000 mm, this potential is spread in the northern part of West Sinjai District, Central Sinjai District, East Sinjai District and South Sinjai. Potential high class landslides with rainfall values in the range of 3000 mm – 3,500 mm are scattered in the District of East Sinjai, District of Central Sinjai, District of South Sinjai and Districts of West Sinjai and Sinjai Borong, while landslide classes are very high grade with a range of rainfall of 3,500 mm – 4,000 mm spread in South Sinjai and Sinjai Borong Districts and parts of Sinjai Tellulimpoe District. The distribution can be seen in figure 3.

![Figure 3. Rainfall](image_url)

Throughout the year, Sinjai Regency is a sub-tropical area, which is known for 2 (two) seasons, namely the rainy season in the April-October period, and the dry season which runs in the October-April period. Of all the types of climate available, Sinjai Regency has rainfall ranging from 2,000 – 4,000 mm / year, with rainy days varying between 100 - 160 rainy days / year. Average air humidity, recorded in the range of 64-87%, with average air temperatures ranging from 21.1°C - 32.4°C.

4. Conclusion
The effect of land use change results in the decreasing the quality of the watershed. Rainfall is one of the factors affecting landslides in the watershed area.
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