Impact of land use change on hydrological conditions in the Karajae watershed, South Sulawesi Province

Chairil A1, Syamsu Rijal1, Munajat Nursaputra1 and Muh. Faisal Mappiase2

1Laboratory of Forestry Planning and Information System, Faculty of Forestry, Hasanuddin University, Makassar, Indonesia
2Faculty of Agriculture, Animal husbandry, and Forestry, University of Muslim Maros, Indonesia

Email: chairil@unhas.ac.id

Abstract. Land use is a representation of activities and utilization of land resources by the community. Land use has a big influence on the hydrological condition of a watershed. One of the small watersheds, in general, is the Karajae watershed, but it has a very large impact on the City of Pare-Pare, and the surrounding community. The Karajae watershed is the main water source for the people of Pare-Pare and agriculture. This study aims to analyze land use patterns that have a major impact on hydrological conditions in the Karajae watershed. The analysis begins with remote sensing methods to interpret land use using Landsat 7 image data in 2010 and Landsat 8 imagery in 2020. Next, analyze the pattern of land use change in detail in each forest area with a geographic information system approach. Analysis of hydrological conditions using the Soil and Water Assessment Tools approach with the input of the land use data. Land use Change 2010-2020 in the Karajae watershed shows additional land use in the form of settlements, rice fields, and dryland agriculture as a form of community activity. There are two forest areas in the Karajae watershed, namely production forest and protected forest. Production forest is dominated by dryland agriculture in the form of corn, beans, and horticulture, while the protected forest is dominated by and secondary dryland forest. This has an impact on hydrological conditions that there are fluctuations in discharge and an increase in sediment a decade ago. Optimal application of forest functions reduces discharge and sediment. Different forest planning for each forest function and land use within. Production forest with many activities directed towards community-based forest management such as community forest and village forest. As for the Protected Forest, which is dominated by grassland and shrubs, forest rehabilitation is carried out.

1. Introduction
Land use is a representation of activities in the form of the use of land resources by humans to meet their needs. The human population has increased rapidly in recent decades, prompting an increasing demand for food over time [1]. This causes changes in land use more quickly as well. Changes in land use do not only occur in the downstream area, which is flat, which is used for use, use, and intensive agricultural land but also occur in the upstream watershed area, which is ideally maintained as a conservation area [2,3].
Changes in land use will have an important role in influencing the condition of hydrological ecosystems or watersheds because one of the land use variables is very dynamic [4,5]. In more detail, changes in land use will have an impact on increasing surface runoff, changes in river discharge, and sedimentation results [4]. These events will stimulate environmental degradation such as air quality due to sedimentation and further natural disasters such as floods. Temporal and spatial land use changes were analyzed using remote sensing approaches, and geographic information systems (GIS) which showed better and more efficient results [6].

Hydrological modeling using spatial and temporal data uses the Soil and Water Assessment Tools (SWAT) model [4,7]. SWAT is a model developed by the United States Department of Agriculture (USDA) to model hydrology at the watershed scale [8]. The application of SWAT provides good information about the condition of a watershed [9]. Soil and Water Assessment Tools give good results in predicting water discharge by calibrating and validating the SWAT model for a period of time and at a certain location [7].

One of the watersheds of concern is the Karajae watershed. Administratively, the upstream of the Karajae watershed is in Sidenreng Rappang Regency, while the downstream is in the City of Pare-Pare. The Karajae watershed is also the main source for the people of the city of Pare-Pare for consumption, and agricultural land such as rice fields. So, the good or bad condition of the Karajae watershed has a great influence on the City of Pare-Pare, and the community itself.

Based on this, it is necessary to conduct research related to "Analysis of the Impact of Land Use Change on Hydrological Conditions in the Karajae River Basin". This research is expected to be the basis for forest management planning activities to land management for environmental balance.

### 2. Methods

#### 2.1. Research location

This research was carried out for three months starting from March to May 2021. This research was carried out in the Karajae watershed area, covering the administrative area of Pare-Pare City and Sidenreng Rappang Regency, which can be seen in Figure 1.

![Figure 1. Research location map.](image-url)
2.2. Data
The tools used in this study include: GPS receiver, camera and laptop. The materials used are tabulated and spatial data including watershed boundaries, main rivers, tributaries, 10-meters contours, soil types, climate data, Landsat 7 satellite imagery data in 2010, and Landsat 8 in 2020.

2.3. Research approach
This research is based on mapping which is classified as non-experimental research using methods, GIS analysis, remote sensing, and hydrological modeling. Remote sensing and GIS approaches to land use analysis and their changes over a decade. Hydrological analysis for hydrological conditions is a digital elevation model (DEM), land use, soil type, and climate data using the SWAT model.

2.4. Data analysis
2.4.1. Land use change. The analysis begins with an analysis of land use changes using time series satellite imagery. The satellite images used are Landsat 7 images in 2010, and Landsat 8 images in 2020 Path 114 and Row 63 with a resolution of 30 meters. The two Landsat images are interpreted by means of image interpretation starting with the merging of color bands. After combining the color bands, then digitize using the visual delineation method. Determination of land use based on patterns and characteristics, namely hue, color and texture in the two images.

The next step after performing image interpretation is to test the accuracy of image interpretation. The accuracy of the results of image interpretation by comparing the results of image classification with checking conditions in the field. The level of accuracy of an acceptable image interpretation is greater than 85% [10]. Checking the conditions in the field by setting the coordinates of the points that represent each land use resulting from image interpretation. The process of testing the accuracy of image interpretation is analyzed using the overall accuracy method with the following equation:

\[ OA = \frac{X}{N} \times 100\% \]  \hspace{1cm} (1)

Where:
X = Number of points from image interpretation according to field checks
N = Total number of field check points

| Table 1. Confusion matrix. |
|---------------------------|
| Field Observation | Column Total |
| Image Interpretation | A | B | C |
| Xn | Xk+ |
| B |
| C | XKK |
| Line Total | X+k | N |

Source: Susanto (1994) [11].

After the results of image interpretation are assessed as accurate, then the next step is to look at the conditions of land use changes. This is analyzed using the Geographic Information System by overlaying land use data in 2010, and land use in 2020. The overlay results describe changes in land use patterns that occur and the size of the area. Analysis of land use change using remote sensing methods and GIS shows better results [6].
2.4.2 Hydrological condition. The Hydrological analysis is river water discharge and sediment yield using the SWAT model. The SWAT model starts from preparing the data in a raster form and creating a SWAT project. Furthermore, watershed boundary delineation consists of the stages of DEM data entry, stream definition, outlet definition, watershed outlet selection, and definition and calculate subbasin parameters. The next stage is the formation of the Hydrology response unit (HRU), that HRU is the smallest unit in the scale of analysis conducted on SWAT modeling. HRU formation is done by overlaying spatial data on land use, soil type maps, and slope data from DEM data with slope class classification of 0-8%, 8-15%, 15-25%, 25-40%, and > 40% based on the Ministry of Forestry's classification in 2009 [12]. After HRU is the stage of organizing data entry, which is the merging of HRU and climate data. Climate data for 2011-2020 is in the form of daily measurements such as rainfall in units (mm), air temperature in units (°C), air humidity (fraction), solar radiation (MJ/m²), and wind speed (m/s).

The final stage is running or simulating the SWAT Model. Simulation of the SWAT model by setting the time period, the SWAT version, and the amount of output time in the form of monthly data. Next run the SWAT model to produce hydrological conditions. SWAT simulation results generate SWAT output summarized in output files consisting of HRU, SUB, and RCH. Water discharge and sediment at yield are in the RCH section, that water discharge data is symbolized by flow out, and sedimentation is symbolized by sed_out [13]. The prediction of water discharge in the SWAT Model with the surface flow is calculated based on the SCS curve number method. Prediction of sediment yield in the SWAT model by diverting the volume of surface runoff, peak runoff rate, and physical conditions of erosion using the MUSLE (Modified Universal Soil Loss Equation) method [14].

The SWAT model will be carried out three times simulations because it will simulate different types of land use change. The three land use are land use 2010 (past), land use 2020 (actual), and forest area optimization. Optimization of forest areas is one part of the ideal land use in a watershed. Other data in the form of DEM data, soil type, and climate are considered the same. So that the impact of land use change will be seen on the hydrological conditions in the Karajae watershed, this will certainly have an impact on the City of Pare-Pare.

3. Result and discussion

Based on the results of the analysis using these eight principles, the description of the performance of the MDK institutions in TNGR is as follows:

3.1. Land use

Actual land use was analyzed by interpretation of Landsat 8 the Year 2020 imagery in the Karajae watershed (Table 2 and Figure 2). The land use classification is adjusted to the land cover class from the Directorate General of Environmental Planning and Planning, Ministry of Environment and Forestry. Land use is dominated by dryland agriculture, while forest land use is only 15.7 percent of the total area of the Karajae watershed.
The validity of the 2020 land use analysis is recognized, so the accuracy test is carried out. The accuracy test is part of the image interpretation analysis stage to measure the confidence of the land use interpretation carried out. The analysis compares the results of image interpretation with field observations (overall accuracy). In more detail, the determined sample points for the results of the land use analysis (Figure 3) are juxtaposed with the results of field observations shown in the Confusion Matrix Table (Table 3).

The number of sample points observed in the field is 5 samples for each land use class. The accuracy test with overall accuracy and the confusion matrix table shows 33 points that match between the sample points of land use interpretation and field checking, while 2 points do not match. This shows that the accuracy of the image interpretation results is $33/35 = 94.27\%$. This indicates that the results of the image interpretation carried out are accepted because the level of accuracy is above 85 percent [10]. This legitimizes an acceptable 2010 land use interpretation, and further analysis can be carried out.

Table 2. Land use 2020 (actual) in the Karajae watershed.

| No | Land Use                | Area (ha) | Percentage (%) |
|----|-------------------------|-----------|----------------|
| 1  | Secondary Dryland Forest| 2,767.78  | 15.70          |
| 2  | Settlement              | 1,004.94  | 5.70           |
| 3  | Dryland Agriculture     | 8,495.65  | 48.19          |
| 4  | Grassland               | 2,332.54  | 13.23          |
| 5  | Rice Fields             | 1,090.13  | 6.18           |
| 6  | Shrubs                  | 1,875.53  | 10.64          |
| 7  | Water                   | 63.52     | 0.36           |
|    | Total                   | 17,630.09 | 100.00         |

Figure 2. Land use 2020 in the Karajae watershed.
Figure 3. Land use field observation points 2020 in the Karajae watershed.

Table 3. Confusion matrix of the land use classification sample points 2020 in the Karajae watershed.

| Closing Land | Field Observation 2021 |
|--------------|------------------------|
| P1 | P2 | P3 | P4 | P5 | P6 | P7 | Total |
| P1 | 5  | 0  | 0  | 0  | 0  | 0  | 0  | 5  |
| P2 | 0  | 5  | 0  | 0  | 0  | 0  | 0  | 5  |
| P3 | 0  | 0  | 5  | 0  | 0  | 0  | 0  | 5  |
| P4 | 0  | 0  | 0  | 5  | 0  | 1  | 0  | 6  |
| P5 | 0  | 0  | 0  | 0  | 5  | 0  | 0  | 5  |
| P6 | 0  | 0  | 0  | 0  | 0  | 4  | 0  | 4  |
| P7 | 0  | 0  | 0  | 0  | 0  | 0  | 5  | 5  |
| Total | 5  | 5  | 5  | 5  | 5  | 5  | 5  | 35 |

Description:
P1 = Secondary Dryland Forest
P2 = Settlement
P3 = Dry Agriculture
P4 = Grassland
P5 = Rice Fields
P6 = Shrubs
P7 = Water
The area function of the area affects the land use in the area. The function of the area is based on the determination by the Government, in this case, the Ministry of Environment and Forestry, the Karajae watershed consists of areas for other uses, production forests, and protected forests. The land use based on area function can be seen in Table 4.

| No. | Area Function | Land Use               | Area (ha) | Percentage (%) |
|-----|---------------|------------------------|-----------|----------------|
| 1   | Others Area   | Secondary Dryland Forest | 16.13     | 0.22           |
| 2   | Settlement    |                        | 981.05    | 13.62          |
| 3   | Dryland Agriculture |                  | 4,367.69  | 60.65          |
| 4   | Grassland     |                        | 500.62    | 6.95           |
| 5   | Rice Fields   |                        | 949.97    | 13.19          |
| 6   | Shurbs        |                        | 383.71    | 5.33           |
| 7   | Water         |                        | 2.05      | 0.03           |
|     | Others Area Total |                  | 7,201.23  | 100.00         |
| 1   | Production Forests | Secondary Dryland Forest | 1,773.47  | 23.67          |
| 2   | Settlement    |                        | 23.07     | 0.31           |
| 3   | Dryland Agriculture |                  | 3,882.80  | 51.82          |
| 4   | Grassland     |                        | 679.25    | 9.07           |
| 5   | Rice Fields   |                        | 133.68    | 1.78           |
| 6   | Shurbs        |                        | 942.96    | 12.59          |
| 7   | Water         |                        | 57.43     | 0.77           |
|     | Production Forests Total |                | 7,492.67  | 100.00         |
| 1   | Protected forests | Secondary Dryland Forest | 978.18    | 33.31          |
| 2   | Settlement    |                        | 0.82      | 0.03           |
| 3   | Dryland Agriculture |                  | 245.16    | 8.35           |
| 4   | Grassland     |                        | 1,152.67  | 39.26          |
| 5   | Rice Fields   |                        | 6.48      | 0.22           |
| 6   | Shurbs        |                        | 548.86    | 18.69          |
| 7   | Water         |                        | 4.03      | 0.14           |
|     | Protected Forests Total |                | 2,936.19  | 100.00         |
|     | Grand Total   |                        | 17,630.09 | -              |

The Karajae watershed has two forest areas, namely production forest and protected forest. Based on the statutory regulations on forestry, the requirement for an area to have a forest area of at least 30 percent of its total area. The Karajae watershed exceeds this because almost 60 percent is included in the forest area. The thing to be concerned about is that most of the forest areas in the Karajae watershed are not covered by forest. Protected forests which should have the function of protecting life support systems for water management, preventing flooding, controlling erosion, and maintaining soil fertility, are only covered by forest about 33 percent of the protected forest area. Grassland and shrubs are the dominant lands uses in protected forests.
3.2. Land use change

Land use is a very dynamic earth biophysical condition that changes from time to time caused by natural and human factors. Data on land use changes based on the interpretation of Landsat 7 in 2010 and 2020 in the Karajae watershed can be seen in Table 5 and Figure 4. Changes in land use are relatively small during one period in the Karajae watershed covering an area of 227 hectares or about 23 hectares per year. Agricultural land, settlements, and rice fields have increased in area. Agricultural and urban land is a community choice to meet the needs of life from the demand and increase in population percent [1]. Secondary dryland forests, grassland and shrubs have decreased in area. The decline in secondary dryland forest area is small compared to the average rate of deforestation for countries in Southeast Asia percent [15].

Table 5. Land use change 2010-2020 in the Karajae watershed.

| No. | Land Use                | 2010 (ha) | 2020 (ha) | Area Change 2010-2020 (ha) | Percentage Change 2010-2020 (%) |
|-----|-------------------------|-----------|-----------|-----------------------------|---------------------------------|
| 1   | Secondary Dryland Forest| 2,773.36  | 2,767.78  | -5.58                       | -0.03                           |
| 2   | Settlement              | 869.7254  | 1,004.95  | 135.22                      | 0.77                            |
| 3   | Dryland Agriculture     | 8,420.10  | 8,495.65  | 75.54                       | 0.43                            |
| 4   | Grassland               | 2,490.09  | 2,332.54  | -157.54                     | -0.89                           |
| 5   | Rice Fields             | 1,074.06  | 1,090.13  | 16.07                       | 0.09                            |
| 6   | Shurbs                  | 1,939.24  | 1,875.53  | -63.71                      | -0.36                           |
| 7   | Water                   | 63.52     | 63.52     | 0                           | 0                               |
| Total|                         | 17,630.09 | 17,630.09 | -                           | -                               |

Figure 4. Land use change 2010-2020 in the Karajae watershed.
Secondary dryland forest, grassland, and shrubs have decreased in area of land use. Changes in land use to settlements mostly come from agricultural land such as dry land agriculture and rice fields. This is almost the same in some areas that dry land agriculture has been converted to built-up land, including settlements [3]. However, dryland agriculture continues to experience an increase in overall area. Conversion to agricultural land is mostly from unused land such as shrubs and grassland [16]. Dryland agriculture as a form of activity found several types of plants such as horticulture, corn, and beans.

3.3 Hydrological Condition. The impact of land use changes on hydrological conditions was analyzed using the SWAT model. The SWAT model begins with project creation, watershed delineation, HRU formation, data input settings, and SWAT model simulation. Watershed delineation uses DEM data, then the results of watershed delineation become the basis for cutting data to enter in the HRU in the form of land use, soil type, and slope. There are three land use data used, namely land use 2010, land use 2020, and forest area optimization. Soil type data used from the Regional Physical Project for Transmigration (RePPProt) land system data (Table 6 and Figure 5). While the slope data are derived from analysis of DEM data used in the watershed delineation stage (Table 7 and Figure 6). Most soils with good hydrological conditions. The slope conditions are quite diverse in the Karajae watershed.

| No. | Soil Types                  | Soil Hydrology | Erodibility | (ha)  | (%)  |
|-----|-----------------------------|----------------|-------------|-------|------|
|     |                             |                | K1 | K2 | K3 |       |
| 1   | Dystropepts; Dystrandepts;  | A              | 0.09 | 0.03 | 0.28 | 447.44 | 2.54 |
|     | Tropaquepts                 |                |       |     |     |       |      |
| 2   | Dystropepts; Humitropepts;  | A              | 0.09 | 0.03 | 0.03 | 5,296.81 | 30.04 |
|     | Tropohumults                |                |       |     |     |       |      |
| 3   | Dystropepts; Tropudalfs;    | A              | 0.09 | 0.06 | 0.08 | 4,607.29 | 26.13 |
|     | Tropudults                  |                |       |     |     |       |      |
| 4   | Dystropepts; Tropudults     | A              | 0.09 | 0.08 | 0.01 | 132.06 | 0.75  |
| 5   | Dystropepts; Tropudults     | A              | 0.09 | 0.08 | 0.65 | 4,349.38 | 24.67 |
|     | Tropothents                 |                |       |     |     |       |      |
| 6   | Eutropepts                  | D              | 0.19 | 0.01 | 0.01 | 2,797.11 | 15.87 |
|     |                             |                |       |     |     |       |      |
|     | Total                       | -              | -    | -    | -    | 17,630.09 | 100.00 |
Figure 5. Soil Types in the Karajae watershed.

Figure 6. Slope in the Karajae watershed.
Table 7. Classification of slope in the Karajae watershed.

| No | Slope (%) | (ha)    | (%)  |
|----|-----------|---------|------|
| 1  | < 8       | 3,826.17| 21.70|
| 2  | 8 - 15    | 2,661.52| 15.10|
| 3  | 15 - 25   | 3,025.23| 17.16|
| 4  | 25 - 40   | 3,293.41| 18.68|
| 5  | > 40      | 4,823.77| 27.36|
|    | Total     | 17,630.09| 100.00|

Managing input data by combining HRU stage results and climate data. Climate data in the form of rainfall in units (mm), air temperature in units (°C), humidity (fraction), solar radiation (MJ/m²), and wind speed (m/s). Climate data were obtained from the Pompengan Jeneberang River Basin (BBWS) Climate Observation Station, Director General of Water Resources, Ministry of Public Works in 2010-2020 (Table 8). Rainfall is quite high with the peak of the rainy season in December, while the peak of the dry season in August in the Karajae watershed.

SWAT simulation by adjusting the period and amount of time data output. SWAT simulations were carried out three times because by comparing land use 2010, land use 2020, and forest area optimization (Figure 7). Based on this, hydrological conditions are compared in the form of water discharge (Table 8) and sediment yield (Table 9). The SWAT model is able to provide information about water discharge in a watershed [17]. Water discharge and sediment yield come from river outlets.

The rainy season starts in October, which is marked by increased water discharge. So that at the height of the rainy season in December, it is also marked by the peak of water discharge at that time. The fall in rainfall, which began in January to September, is also evidenced by the decrease in water discharge. Peak water discharge at that time is higher in simulation with land use 2020. Water discharge is very low in September as the peak of the dry season, the lowest water discharge is also in the land use 2010. This shows that there is a huge fluctuation in water discharge compared to the land use 2010. Fluctuations in water discharge in the forest area optimization are much smaller compared to the land use 2010, and 2020.
Figure 7. Forest area in the Karajae watershed.

Table 8. Water discharge every month with various land use change simulations in the Karajae watershed.

| No. | Month   | Water Discharge m/s | Land Use 2010 | Land Use 2020 | Forest area optimization |
|-----|---------|----------------------|---------------|---------------|--------------------------|
| 1   | January | 17,3025              | 17,3104       | 17,2756       |                          |
| 2   | Februari| 15,4905              | 15,0961       | 15,1646       |                          |
| 3   | March   | 13,618               | 13,6224       | 3,752         |                          |
| 4   | April   | 12,8941              | 12,8897       | 12,9273       |                          |
| 5   | May     | 11,7312              | 11,723        | 11,7083       |                          |
| 6   | June    | 9,8523               | 9,8517        | 9,8438        |                          |
| 7   | July    | 7,8366               | 7,8344        | 7,8673        |                          |
| 8   | August  | 4,5221               | 4,5153        | 4,5463        |                          |
| 9   | September| 4,3775              | 4,3733        | 4,3752        |                          |
| 10  | October | 8,0622               | 8,0659        | 7,9977        |                          |
| 11  | November| 9,5062               | 9,5104        | 9,4854        |                          |
| 12  | December| 19,5759             | 19,5819       | 19,4086       |                          |
Changes in land use greatly affect the hydrological conditions in the Karajae watershed. The dynamics of land use change are very sensitive to hydrological responses [4]. Urbanization activities that cause an increase in areas built and settlements have quite an impact on hydrological conditions in a watershed [18]. The forest area optimization based on the rules of land use further safeguards the stability of hydrological conditions. An increase in forest area will reduce surface runoff and peak discharge [19]. The addition of forest area will also reduce the impact of urbanization and the addition of changes to peak discharge [20].

Like water discharge, sedimentation also has the same pattern by looking at rainfall conditions. The increase in built area and the land agriculture significantly increased sediment yield [18, 21]. The forest area optimization as an ideal form of land use has succeeded in reducing sediment yield. The decrease in sediment with the forest area optimization reached more than 500 thousand tons for one year from the actual condition.

Optimizing forest areas in accordance with their functions based on land use rules to maintain hydrological conditions. The regulation of forest area functions is an activity of planning to regulate the types of land use in an area so that they can be used optimally, namely giving high yields and protecting the environment. Optimizing the forest area by conducting forest management based on its function and current land use conditions.

Management of protected forests whose land use is mostly covered by grassland and shrubs. Based on this, the protected forest area is directed to be rehabilitated in the Karajae watershed. Meanwhile, production forest management is directed towards community-based forest management, such as community forest (HKm) and village forest (HD). Community-based forest management because land use in production forests is mostly covered by dryland agriculture. Community-based forest management with agroforestry patterns can overcome hydrological, social, and economic conditions.

Table 9. Sediment yield every month with various land use change simulations in the Karajae watershed.

| No. | Month   | Sediment (ton)                      |
|-----|---------|------------------------------------|
|     |         | Land Use 2010 | Land Use 2020 | Forest area optimization |
| 1   | January | 168,815.96   | 169,897.48   | 83,249.77                |
| 2   | February| 94,297.18    | 95,279.59    | 46,687.00                |
| 3   | March   | 48,178.72    | 48,598.36    | 23,813.20                |
| 4   | April   | 23,300.72    | 23,520.66    | 11,525.12                |
| 5   | May     | 30,924.38    | 31,305.94    | 15,339.91                |
| 6   | June    | 13,148.87    | 13,678.60    | 6,702.51                 |
| 7   | July    | 13,099.48    | 13,349.06    | 6,541.04                 |
| 8   | August  | 12,460.63    | 12,572.69    | 6,160.62                 |
| 9   | September| 16,679.81   | 16,909.91   | 8,285.86                |
| 10  | October | 99,029.32    | 100,154.86   | 49,075.88                |
| 11  | November| 95,674.36    | 97,491.93    | 47,771.05                |
| 12  | December| 249,492.84   | 249,973.42   | 122,486.98               |
|     | Total   | 865,102.27   | 872,732.50   | 427,638.93               |
4. Conclusion
Land use Change over the past decade in the Karajae watershed shows that additional land use is not too extensive. Land use that has increased in area in the form of settlements, rice fields, and dry land agriculture as a form of community activity. There are two forest areas in the Karajae watershed, namely production forest and protection forest. Production forest is dominated by dryland agriculture in the form of corn, beans, and horticulture, while protection forest is dominated by grassland and secondary forest. Changes in land use have quite an impact on hydrological conditions, such as fluctuations in discharge and an increase in sediment. Optimal application of forest functions reduces discharge and sediment. Different forest planning for each forest function, and land use within. Production forest with many activities directed towards community-based forest management such as community forest and village forest. As for the Protected Forest which is dominated by grassland and shrubs, forest rehabilitation is carried out.

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