Compatibility of land use with spatial patterns of the Saddang Hulu Subwatershed

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Abstract. This study aimed to identify the land use and analyze the compatibility between land use with the spatial pattern of the Saddang Hulu Subwatershed. This study was conducted from March to May 2018, located in the Saddang Hulu Subwatershed. The data consisted of primary and secondary data, which primary data were collected from the field, and the secondary data were spatial plan and other supporting data. The data were analyzed by interpretation, accuracy test, and determination of compatibility. The results showed that 82.27% of the land use was compatible with the spatial pattern, while 17.73% was not. Incompatible land use directed towards community forestry with agroforestry and intensification patterns.

1. Introduction
Increasing population growth is always followed by development in an area [1]. As the population increases, so does the need for land for various purposes. Land-use shifting is then considered as a solution. This causing decrease in the carrying capacity of the watershed. If this condition is allowed to continue, the area of critical land will undoubtedly increase, which means that flooding and erosion will also occur more frequently, and the rate of sedimentation increasing.

The Saddang Hulu subwatershed with an area of 202,899.21 ha is part of the Saddang watershed. It is located in North Toraja, Tana Toraja, Enrekang, and Pinrang Regencies. Based on the results of field observations, in the Saddang Hulu Subwatershed, many lands were not compatible with the predetermined spatial plan. Although areas with steep to very steep slopes should be a protected area, many local people use it as plantations.

The existence of forests in the Saddang Hulu Subwatershed, as shown in the January 2018 recording image, was decreasing due to the increase in development. In addition, forests are only found on the left and right sides of the river. Severe conditions also found in steep areas, which should be areas with high vegetation cover. However, the current conditions are becoming barren. This situation reflects the discrepancy between land use and spatial plans. Damage due to land conversion that is incompatible with the spatial plan will increasingly affect the damage that occurs in the downstream. By looking at these conditions, it is necessary to research "Compatibility of Land Use with Spatial Patterns of the Saddang Hulu Subwatershed," which aimed to identify land use in the Saddang Hulu Sub Watershed and analyze the compatibility between land use with spatial patterns of the Saddang Hulu Subwatershed.

2. Research methodology
This research was conducted from March 2018 to May 2018 in the Saddang Hulu Subwatershed and Laboratory of Watershed Management, Universitas Hasanuddin.

3. Method of data collection

3.1. Primary data collection

3.1.1. Identified the types of land cover.

3.1.2. Determination of the sampling coordinate points surveyed based on existing land use. Determination of the coordinates of the points that represent each land use was done by marking on the overlay map (overlapping) land use maps with maps of spatial patterns to produce an accurate land use map. The representative of coordinates was determined with purposive sampling by considering the accessibility factor that was 0.5 - 2 km from the road, from each selected land use, and looking at the extent of each land use. Specified sample points were recorded into the GPS.

3.1.3. Conducted survey and data collection in the field, compatible with a predetermined point on the work map by observing the conditions and patterns of land use

3.1.4. Performed data analysis by managing field data and making corrections/corrections.

3.2. Secondary data collection
Data and information were obtained from various agencies and related government agencies, such as the Regency Spatial Planning map.

3.3. Data analysis

3.3.1. Image interpretation. Land cover maps derived from satellite imagery using Landsat 8 Path 114 Row 62 imagery in January 2018. These images can be downloaded via the website http://earthexplorer.usgs.gov. Then the interpretation began with the merging of the color bands (composite band). Furthermore, digitization was done by digitizing on-screen, which relying on visuals. Land use classes were determined based on patterns and characteristics (hue, color, and texture) of the image.

3.3.2. Accurate test. In order to test the accuracy of image interpretation, an image classification accuracy test was performed, which aims to determine the extent of the accuracy of image interpretation that had been done according to Lillesand and Kiefer (1997) in Saripin (2003). This process is called overall accuracy with the following equation:

\[ OA = \frac{x}{N} \times 100\% \]

\[ x = \text{The sum of the diagonal matrix values} \]
\[ N = \text{number of matrix samples} \]

3.3.3. Determination of Compatibility. The analysis used in this study was a spatial analysis by using GIS (Geographic Information System) software to analyze the compatibility of land use by overlapping land-use maps with spatial pattern map. After overlaying, the determining of land use compatibleness was based on the forest with its designation that had been determined in the regional spatial plan.

The spatial pattern is the distribution of spatial allotments in an area which includes:

a. Space for protected areas
b. Space for the area of cultivation

4. Result and discussion
The results of image interpretation and field observations on land use in the Saddang Hulu Subwatershed were known to have 11 classifications and are presented in Table 1.

| Classification of Land Use | Area (ha) | Percentage (%) |
|----------------------------|-----------|----------------|
| Secondary forest           | 26,530,36 | 13.09          |
| Primary forest             | 5,090,26  | 2.51           |
| Residential area           | 1,846,37  | 0.91           |
| Dryland agriculture        | 8,272,89  | 4.08           |
| Plantation                 | 480,77    | 0.23           |
| Paddy field                | 25,851,01 | 12.75          |
| Shrub                      | 20,890,18 | 10.30          |
| Grassland                  | 10,939,16 | 5.39           |
| Dryland agriculture mixed with shrubs | 101,931,08 | 50.29 |
| Airport                    | 70,16     | 0.03           |
| Waterbody                  | 752,23    | 0.37           |

**Grand Total** 202,654.47 100.00

Based on Table 1, the broadest distribution of land use was dryland agriculture mixed with shrubs with an area of 101,931.08 ha (50.29%), then followed by secondary forest, which covered 26,530.36 ha (13.09%) with teak, pine, and bamboo commodities. While the least area was an airport with an area of 70.16 ha (0.03%).

Based on the results of the ground check in the field, there were several points which found to be incompatible with the results of the image creation map and the real condition. It was due to the low level of accuracy, and the result of image resolution in an object could not be distinguished with certainty. This was in line with the study of Lillesand and Kiefer (1997) in Saripin (2003) about the importance of checking objects in the field [2].

The accuracy test was done with the confusion matrix table to determine the percentage of the level of confidence from the interpretation of the Landsat 8 image in 2018. The number of corresponding points in the field was then divided by the total number of sample points and times by 100. The results showed the percentage level accuracy of image interpretation. Confusion matrix table for the 2018 closing classification shown in Table 2.

**Table 2.** Confusion matrix for the 2018 closing classification of Saddang Hulu Subwatershed

| Land cover                | 2018 Field Data | Amount |
|---------------------------|-----------------|--------|
| February 2018 Classification Data | P1  | P2  | P3  | P4  | P5  | P6  | P7  | P8  | P9  | P10 | P11 |
| P1                        | 0   | 10  |     |     |     |     |     |     |     |     |     |
| P2                        | 10  |     |     |     |     |     |     |     |     |     |     |
| P3                        | 10  |     |     |     |     |     |     |     |     |     |     |
| P4                        | 10  |     |     |     |     |     |     |     |     |     |     |
| P5                        | 10  |     |     |     |     |     |     |     |     |     |     |
| P6                        | 10  |     |     |     |     |     |     |     |     |     |     |
| P7                        | 10  |     |     |     |     |     |     |     |     |     |     |
| P8                        | 10  |     |     |     |     |     |     |     |     |     |     |
| P9                        | 10  |     |     |     |     |     |     |     |     |     |     |
| P10                       | 10  |     |     |     |     |     |     |     |     |     |     |
Based on Table 3, 166,741.47 ha (82.27%) of the land area was compatible, and 35,913 ha (17.73%) was incompatible with the land use compatibility. Based on the Regional Spatial Plan that the borderline in the Saddang Hulu Subwatershed area designated for cultivation and protected areas. With the vast use of dryland agriculture, most of the community in the Saddang Hulu Subwatershed work as farmers. The land was planted with annual crops. Communities in the Saddang Hulu Subwatershed often utilized land from flat to steep slope conditions. It could be seen from the high percentage of dryland agriculture in the Saddang Hulu Subwatershed, which was 50.29%. The land use in the form of dryland agriculture compatible with the spatial plan. Cultivation in dryland agriculture adds economic value to the farmers because it can be sold to the community. The economic value obtained by the community is beneficial compared to the use of rice fields and gardens [3].

The community began to enter the forest area to fulfill their daily needs. Based on Table 1, land use in the form of plantations had an area of 480.77 ha with commodities cultivated such as coffee, cocoa,
cloves, and vanilla. The highest number of commodities produced were coffee and chocolate, especially in Bokin and Nanggala villages.

Land use for plantations is one of the major causes of loss in forest areas. The community converts forests into coffee and cocoa plantations. The plantations are generally in areas with 25 - 45% of steep slopes. From the result of overlaying, the use of plantation land was compatible with the specified spatial pattern plan. The same case in cocoa plantations in Kolaka showed the good plantation with genetics and environmental factors [4][5]. Still, the area should be designated as a protected area due to steep slope conditions.

The residential area in the Saddang Hulu Subwatershed area was 1,846.37 ha, which is depicted in Table 1. Rapid population growth each year, causing communities to develop residential areas by utilizing forests and dryland agriculture. Based on population data in 2016, the highest number of population in North Toraja Regency, was 26,988 people, the broadest area in the Saddang Hulu Subwatershed. The majority of the residential area located on a flat slope, while agricultural and plantation activities mostly located in areas with steep topography.

Land use for rice fields in the Saddang Hulu Subwatershed area was 25,851.01 ha (12.75%), with rice (Oryza sativa) as its commodity. Besides that, the community also utilized the rice field as an agro-fishery area.

Survey and observation results showed that some rice fields in the Saddang Hulu Subwatershed located on steep slopes (25 - 45%); thus, bench terraces were made. The community has long been implementing bench terraces, so it is not easily eroded. Arsyad (2010) stated that bench terraces could reduce the length of slopes and hold water [6], thereby reduce the speed and amount of surface runoff and allow absorption of water by the soil. Besides that, grass can also increase the effectiveness of the bench terrace because it can reduce the impact of raindrops. However, the high dependency of the population with agriculture without regard to the preservation of land resources causes faster land damage, thereby reducing land productivity.

After knowing the land use of the Saddang Hulu Subwatershed, it would be better to return to the specified spatial pattern. However, if relocation is not possible, efforts can be made to conduct land use referrals. In the Saddang Hulu Subwatershed, land use policy is carried out in a Community Forest pattern with an agroforestry system. Based on Minister of Forestry Regulation No.P.88/Menhut-II/2014 article 6 regarding Community Forestry that forest areas that can be designated as Community Forest areas are protected forest and production forest areas.

In the protected forest and production forest areas, there are plants and land uses that have been carried out intensively by the community. In general, protected areas are not allowed inside intensive cultivation activities. But it looks that there are lands for dryland agriculture, plantations and rice fields inside of protected forest areas. With the impact that has occurred, an effort will be made to direct land use. Land use guidance is the community forest pattern, to improve the welfare of local communities through the utilization of forest resources in an optimal, fair, and sustainable manner (Permenhut No.P.88 / Menhut-II / 2014). For community forests developed in production forests, the main types of plants are forest trees (wood producing). They can be mixed with fruit trees and/or multipurpose tree species (fruit/food producers) with a proportion of 2:1 (67% wood and 33% fruit or multipurpose tree). The community forest is developed in the protected forest area so that the main types of plants are not wood. Therefore, the plants/trees are not cut down, for example, shorea producing tengkawang, durian, candlenut, etc.. These types can be mixed with wood-producing species in the proportion of 2:1 (67% multipurpose trees and 33% wood trees) [7].

In protected areas, land use in the form of rice fields, an intensive cultivation activity carried out by the community not permitted in the protected forest; thus, compatible land use directions should be made. The direction of compatible land use is the intensification pattern, which means existing rice fields are maximized and no land extensification. In the area of cultivation, the direction of land use in agroforestry systems. Agroforestry is an intensive land management system that combines forestry plants and agricultural crops in order to obtain
maximum results from these forest management activities without ignoring aspects of land conservation and the practical cultivation of local communities [8].

Use of rice fields, gardens, and dryland agriculture can be done with an agroforestry system, which means forestry plants combined with agricultural crops with spatial arrangements, which forestry plants planted on the embankment or the edge of farmers' land. While garden land use with intercropping patterns between seasonal plants used for plants such as coffee (Coffea arabica) or cocoa (Theobroma cacao) and annual plants such as sengon (Albizia chinensis). Meanwhile, dryland agriculture is directed to grow annual crops like teak (Tectona grandis) as a 'divider' of land owned by farmers. By applying agroforestry planting patterns, there are two benefits that are produced in terms of economy and ecology. As stated by Suryani and Dariah (2012) [9], agroforestry as one form of soil and water conservation practices to protected soil from erosion and produced some products that have a high economic value.

5. Conclusion

Based on the research results obtained, it can be concluded that:

1. There were 11 classifications on Land use in the Saddang Hulu Subwatershed, namely secondary forest, primary forest, residential area, dryland agriculture, dryland agriculture mixed with shrubs, plantation, paddy field, shrubs, grassland, airport, and waterbody.

2. Based on the results of the analysis of land compatibility with the spatial pattern, it showed that the land use compatible with the spatial pattern was 166,741.47 ha (82.27%) and 35,913 ha (17.73%) was not. Incompatible land use directed towards community forestry with agroforestry and intensification patterns.

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