Compatibility of land use with spatial patterns of the Pangkajene Watershed

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Abstract. This research purposed was to investigate land use and identify the suitability of land use with spatial patterns as well as determine the suitability between land use with regional spatial plans in the Pangkajene watershed. Two types of data were collected in the study; primary data in the form of land use data, and secondary data as the spatial plan map. The data obtained were analyzed by interpretation, accuracy test, and overlay to determine the suitability of land use with spatial patterns. The results showed ten classifications of land use. The land use, which compatible with the spatial pattern, was 68.08%, and 31.92% was not. The directions for use are in the form of reforestation on secondary forest land use, grasslands, mixed-land dryland agriculture, and shrubs. Land use management can be applied with reforestation, animal farming, and construction of terraces, both accompanied by ground cover plants and terrace reinforcement in the use of paddy fields.

1. Introduction

The land is a natural resource used as a place for development [1]. The development purpose is to improve the standard of living and open opportunities to meet the needs of the community. However, more development means high demand for land, which causes shifts in land use to more profitable activities. Incompatible land use from the Regional Spatial Plan can destroy the ecosystem in general, especially in the watershed.

One of the efforts in watershed management for the suitability of land use for environmental sustainability is drafting watershed Regional Spatial Plan, which prepared by the Regency Governments. The land use directive function can be used as a parameter in the preparation of the spatial pattern since space usage has been grouped based on spatial structure and pattern [2].

Based on data from the Makassar Region VII Forest Area Consolidation Center, the Pangkajene watershed experienced a change in forest area since 1990 with primary forest area (11,957.11 Ha), secondary forest (6.13 Ha) while in 2014, primary forest area reduced to 3,58 Ha, secondary forest to 11,206.17 Ha. This condition led to overflowing for rivers in the Pangkajene watershed, causing flood and destroyed residential areas in Minasatene, Bungoro, Labakkang, Ma'rang, Segeri, and Mandalle Subdistricts in Pangkep (Disaster Management Agency South Sulawesi, 2017).

The Pangkajene watershed has an area of 42,039.08 hectares, located in four districts, which are Pangkajene and Kepulauan Regency (Pangkep) with an area of 27,987.25 ha, Maros Regency with an area of 415.02 ha, Bone Regency with an area of 5,815.26 ha, and Barru Regency with an area of 7,821.55 ha. The watershed has a vital role in sustaining daily life, especially in the provision of clean water for urban and surrounding communities and also for irrigation, since the community uses the
upstream region of the watershed for agriculture and plantations. Therefore, it is necessary to study the compatibility of land use in the Pangkajene watershed. The purpose of this study was to investigate the land use, to identify compatibility of land use with the spatial pattern, and to determine the land use directive if there was a mismatch between land use with the spatial plan in the Pangkajene watershed.

2. Research methodology

The research was conducted from February to November 2018 in Pangkep watershed and Laboratory of watershed Management Universitas Hasanuddin.

2.1. Data Collection Method

2.1.1. Primary Data
a) It was identified as the type of land cover.
b) It was determined the coordinate sampling points surveyed based on existing land use. These coordinate points represent each land use marked was overlapped with the land use map and with a spatial pattern map, in order to produce an accurate land use map. Representative coordinates were determined with a purposive sampling method by considering the accessibility factor, around 0.5 - 2 km from the road, from each chosen land use, and by looking at the extent of each land use. Specified sample points were recorded into the GPS.
c) Conducted surveys and data collection in the field (cross-check) were in accordance with a predetermined point on the map by observing the conditions and patterns of land use.
d) Conducted data analysis by managing field data

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

2.1.3. Data Analysis
a) 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, digitalization was done by digitalizing on screen, which relying on visuals. Land use classes were determined based on patterns and characteristics (hue, color, and texture) of the image.
b) Accuracy test
   In order to test the accuracy of image interpretation, an image classification accuracy test was performed 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:

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

   \(N\) = number of matrix samples
   \(x\) = The sum of the diagonal matrix values

c) 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 compatibility determination of land use was based on the forest and its designation that has been determined in the regional spatial plan.

   The spatial pattern is the distribution of spatial allotments in an area which includes:
   1. Space for protected areas
   2. Space for the area of cultivation
3. Result and discussion
The results of image interpretation and field observations on land use in the Pangkajene watershed were known to have ten classifications and are depicted in Table 1.

Table 1. Classification of Land Use in the Pangkajene in 2018

| Classification of Land Use                        | Area (ha) | Percentage (%) |
|--------------------------------------------------|-----------|----------------|
| Primary forest                                   | 3.58      | 0.01           |
| Secondary forest                                 | 10,817.81 | 25.73          |
| Grassland                                        | 2,612.51  | 6.21           |
| Residential area                                 | 537.94    | 1.28           |
| Dryland agriculture mixed with shrubs            | 9,887.41  | 23.52          |
| Paddy field                                      | 7,102.97  | 16.90          |
| Shrubs                                           | 9,027.85  | 21.47          |
| Fishpond                                         | 1,308.63  | 3.11           |
| Open field                                       | 377.12    | 0.90           |
| Waterbody                                        | 363.27    | 0.86           |
| Total                                            | 42,039.08 | 100.00         |

Based on Table 1, the smallest perimeter is the primary forest area (0.01%) located in the upper of the Pangkajene watershed. While the most extensive land use is secondary forest (25.73%), which based on field observations contained pine, teak, candlenut, sugar palm, mango, and bamboo as the commodities. Pine trees are generally found in high altitudes, while teak thrives mixed with hazelnut, sugar palm, mango, and bamboo. Both areas cover only 25.74% of the total area of the watershed. However additional 4.26% or about 1,790.74 ha still needs to be added based on Law No. 41 of 1999 about Forestry that a minimum area of forest is 30% of the total watershed area. Then, the dryland agriculture mixed with shrubs area is 23.52% of the Pangkajene watershed area with commodities consist of corn, bananas, and beans. Based on the results of ground check in the Pangkajene watershed, there were several points found to be incompatible between the map of image interpretation result and the real conditions in the field. This difference occurs due to the low level of accuracy and image resolution resulting in an object that can not be distinguished with certainty.

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 then divided by the total number of sample points and then times by 100. The results showed the percentage level accuracy of image interpretation. Confusion matrix table for the 2018 land cover classification shown in Table 2.

Table 2. Confusion matrix for the 2018 land cover classification of Pangkajene watershed

| Land use                | September 2018 Field Data | Amount |
|-------------------------|----------------------------|--------|
|                         | P  | P  | P  | P  | P  | P  | P  | P  | P  | P  |     |
| September 2018 Classification |   |    |    |    |    |    |    |    |    |    |
| P1                      | 1  |    |    |    |    |    |    |    |    |    | 1   |
| P2                      | 37 | 1  |    |    |    |    |    |    |    |    | 38  |
| P3                      | 16 |    |    |    |    |    |    |    |    |    | 16  |
| P4                      | 12 |    |    |    |    |    |    |    |    |    | 12  |
| P5                      | 12 |    |    |    |    |    |    |    |    |    | 12  |
The land use classification in 2018 in the matrix confusion table showed 217 points following the conditions on the ground, and 23 points were not. Based on these results obtained the level of accuracy of the results of the interpretation made at 90.41%, the results of the interpretation made could be accepted. It is under the statement of Lillesand and Kiefer (1997), that image classification can be accepted with a minimum accuracy level of 85%. From the results of ground checking, no primary dryland forest was found.

### Table 3. Percentage of Compatibility of Land Use with Spatial Pattern in Pangkajene watershed

| Land Use Compatibility | Area (ha) | Percentage (%) |
|------------------------|-----------|---------------|
| Compatible             | 28.618,13 | 68.08         |
| Incompatible           | 13.420,96 | 31.92         |
| **Total**              | **42.039,08** | **100.00**   |

Based on Table 4, it is known that the land use that is following the planned spatial map is 68.08%, while the incompatible land use is 31.92%. Incompatible of land use due to lack of public awareness related to spatial patterns set by the government. The spatial pattern itself divided into two areas, such as protected and cultivation areas. The existence of protected areas, especially forests, is a great concern for both regional and international levels; besides, the main function is protecting environmental sustainability.

The current condition of protected areas in the Pangkajene watershed is pathetic, with the remaining primary forest area only 0.01% of the total watershed area, while the remaining secondary forest area is 25.73%. The causes are the conversion of forest areas to non-forestry areas, plantations, and illegal logging. The government targeted the protected areas for 49.29% of the watershed area to encourage better watersheds. The target has been determined through the Regional Spatial Plan.

Secondary forests in the Pangkajene watershed are located in four districts. The largest area in Pangkep Regency is 81.33%, while 18.67% are located in Barru, Bone, and Maros Regencies.
The secondary forest land area of 43.51 ha was converted into open land due to land clearing by the community around the forest. Damaged conditions of land will not provide the maximum function of a forest area. It is necessary to restore the main function of the forest area.

Grassland is a stretch of land that is overgrown with lots of grass, rocks, and some trees. Based on the Spatial Planning, the land-use area in the form of grasslands is considered inappropriate because it is included in a protected area and does not provide maximum protection to its subordinate area, which is water catchment. The area of land use that is in accordance with the Regional Spatial Plan is 1,037.32 ha (39.71%) while 1,575.19 ha (60.30%) is not, since it is located in a protected area with a very steep slope (> 45%). Such conditions make it possible to conduct land use directives to maximize the main function of the area.

There are many residential areas in the downstream part of the Pangkajene watershed that varied from flat to the sloping area. The area is 537.94 ha (1.28%). The community considers these areas as a residential area.

Dryland agriculture mixed with shrubs in the Pangkajene watershed is a type of land use that planted with annual and annual crops by the community. It is the second-largest land use after the secondary forest. The area is 9,887.41 ha (23.52%). The wide scope of land use is because most of the people in the Pangkajene watershed work as farmers.

The characteristic of land use of dryland agriculture mixed with shrubs is not following the Regional Spatial Plan because it is in a protected area with a flat to very steep (25-45%) slopes. The area is used by the community to grow annual crops such as bananas, pineapple, and maize, while for annual crops are cocoa and zalacca. The results of these land uses can bring economic value to the community. It is by the results of a study by Ali (2015) [3] stated that the economic benefits obtained by the community in mixed shrub dryland farming are very beneficial compared with price fields and gardens. Such conditions become a major factor for people to convert forest areas in order to meet their daily needs. Since the majority of people in the Pangkajene watershed are farmers, if agricultural land is no longer fertile, then they will look for new places by clearing land in the forest area and causing deforestation.

Based on the research, the paddy fields in the Pangkajene watershed was rain-fed paddy fields that depend on rainwater. During the dry season, the water supply is reduced. Thus paddy fields are converted into gardens with legumes and corn. It is an intensive cultivation activity carried out by the community. However, this is incompatible with a spatial plan because no cultivation activities are allowed in a protected area. Paddy field has an area of about 16.90% of the total area of the watershed.

Shrubland has an area of 9,027.85 ha and becomes the third largest land use in the Pangkajene watershed. The area of land use that is under the Regional Spatial Plan is 8,611.74 ha, and 416.11 ha is not. Inappropriate land uses are in protected areas with flat to very steep slopes.

From the total number of points visited, there were two points that incompatible with the Regional Spatial Plan, with an area of 416,115 ha. The use of shrubland considered incompatible due to the small number of trees. If returned to the forest function as water infiltration, then the land use is not optimal.

Fishpond has an area of 1,308.63 ha (3.11%) from the total watershed area. Fishpond land use located in the downstream part of the Pangkajene watershed with a flat slope (0-8%). The land use is by the Regional Spatial Plan because it is located in the cultivation area.

Open field in the Pangkajene watershed has a total area of 377.12 ha, the use of open field area is not following the Spatial Plan area is 43.51 ha. Open field occurs due to land clearing or tree cutting by the community around the forest. These activities harm the watershed ecosystem. Some research shows that deforestation can increase the surface flow between 6 to 97%, and forest areas able to reduce water flow. In temperate regions, every 10% of deforestation will increase water flow by 40 mm/year [4]. The use of an open field is considered incompatible if located in the protected area.
3.2. Land Use Directive

Land use directive aims to restore the primary function of land use in accordance with the Regional Spatial Plan. According to Wirosoedarmo et al. (2014) [5], efforts to balance the use of natural resources and the environment are through spatial planning based on environmental functions. These efforts can be guaranteed with spatial use that pays attention to environmental capacity. The carrying capacity of the environment is vital to be considered in spatial planning, both in the preparation of the Regional Spatial Planning and in the evaluation of spatial use.

After overlaying a land-use map with a map of the Regional Spatial Plan, and after conducting field visits in the Pangkajene watershed, it was found that the land use which incompatible would be returned to the specified spatial plan. Besides directives that refer to the Regional Spatial Plan, this research also recommends the directive of soil and water conservation. It is hoped that these conservation directives can reduce the rate of erosion. Thus, it does not occur in a large area and able to guarantee the availability of water for future generations.

The directive of land use for dryland agriculture mixed with shrubs, shrubs, open fields, and grasslands in the Pangkajene watershed is reforestation. Reforestation directives are also given to the animal farming area with additional guidance, like animal stocks area [6]. The direction of reforestation is considered to be able to restore the function that refers to the spatial plan. According to Zainuri (2016) [7], reforestation is replanting trees on deforested land and greening forest areas. It is hoped that reforestation can restore forest function as it should. According to MacKinnon et al., 1990 in Kusmana, et al. 2004[4], which is categorized as a forest is a group of growing trees that have a dense and layered canopy. Vegetation cover plays an essential role in regulating the hydrological system, especially the "sponge effect" which can trap rainwater and drainage as to reduce the tendency of flooding and maintain the flow of water in the dry season.

The directive for the animal farming area is also considered essential to increase soil fertility. It is in line with a study by Sudaryanto and Priyanto (2012) [8] cattle management left animals in the field, in order to provide food for livestock. Grass can improve soil fertility due to the influence of grass plants in soil, grass which is eaten by cattle is returned as fertilizer.

The direction of land use for paddy fields with steep to very steep slopes that previously had a moderate bench patio construction should be changed to a better bench terrace, by providing patio reinforcement (ground cover plants or rocks) and making water channels inside the terrace. Based on the result of the study by Sutapa (2010) [9], in steep slope areas, especially on mountain ridges and riversides, agricultural activities must be accompanied by principles of soil and water conservation, for example by regulating drainage channels, land management on high slopes with bench terraces pattern, and cliff reinforcement.

4. Conclusion

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

There were ten classifications on land use in the Pangkajene watershed, namely primary forest, secondary forest, grassland, residential area, dryland agriculture mixed with shrubs, paddy field, shrubs, fishpond, open field, and waterbody.

Based on the results of the analysis of land compatibility with the spatial pattern, it is obtained that the land use compatible with the spatial pattern was 28,618.13 ha (68.08%) and 13,420.96 ha (31.92%) was not.

Land use management can be done with reforestation, animal farming, and construction of terraces, both accompanied by ground cover plants and terrace reinforcement in the use of paddy fields. It is expected that these directives can be used for soil and waters conservation in the Pangkajene watershed.
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