Analysis of land use change using Landsat image from 2006 - 2016 in Solok Regency

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Abstract. Land use change is an important issue in the regional planning and development. This research uses a remote sensing approach of Landsat images and Geographic Information System (GIS) analysis to detect land use change in Solok Regency by time series of 2006, 2011, and 2016. Land use changes were interpreted through Landsat TM satellite images of 2006 and 2011 and Landsat 8 OLI 2016. GIS is used in analysing land use classifications. Land use classification found in Solok Regency is classified into 9 classes which dominated by primary and secondary forests followed by rice fields, mixed gardens, crop field, water bodies, settlement, shrubs and plantations. Based on the results of research, there is a continue increasing of agricultural and settlement expansion. There also expansion of mixed garden against secondary forests, and then there is a significant expansion of settlement land against the rice field. These results indicate that there has been a change of land conversion from non-cultivation to cultivation, and the development of residential areas.

1. Introduction

Land use is defined as human intervention to the land in order to meet their needs, while land cover changes refer to vegetation changes. Land use changes can generally be observed using spatial data from land use maps from the same point in different years. Remote sensing data such as satellite imagery, radar, and aerial photographs are useful in observing changes in land use. Land use change includes shifting land use to different land use (conversion) or diversifying to existing land use. In general, land use changes will change: 1) river flow characteristics, 2) number of surface streams, 3) hydrological properties of the area [1].

Land use is linked to human activities in certain areas of land. Land use information can be recognized directly by using the appropriate remote sensing. The phenomenon of land conversion is part of the transformation of the national economic structure. Economic growth and populations centering in urban areas require wider space out of town for various economic activities and settlements. As a result, the mostly marginal areas of wetland farming are converting to non-agricultural land with varying transition rates between periods and regions [2]. Land conversion often has interrelated problems, so it is not independent and cannot be solved by partial approaches but requires integrative approaches. The problems are: 1) Efficiency of allocation and distribution of resources from the economic point of view,
2) their relationship with equity and resource control issues, and 3) their relation to degradation process and damage of natural resources and environment.

The development of horizontal moving land uses spatially toward areas that are easy to cultivate. Land use also moves vertically in order to raise its quality [3]. The trigger is the growing population that increases the need for land in order to raise income for the fulfillment of needs and raise the standard of living. Community life in Solok Regency is dominated by people who rely on agrarian based life. The development of spatial land use in Solok Regency benefits from physical factors with sloping areas. Population growth and settlement in the slopes resulted the utilization of space to change. Various phenomenon of land use change has occurred from time to time. Changes in land use that occur in line with the increasing number of people who directly affected the need for land.

2. Method
This research used remote sensing image interpretation method, Geographic Information System (GIS) approach, field survey and spatial based descriptive analysis. Remote sensing image classification is a complex process which involves many steps, including the determination of a land cover classification system, collection of data sources, selection of a classification algorithm, extraction of thematic information, and accuracy assessment [4,5]. The interpretation of remote sensing imagery is done to find out information on actual land use types on previous years based on digital values recorded on remote sensing data. Field survey was conducted to find out the interpretation of land use and environmental conditions. The research location was conducted in Solok Regency, West Sumatera Province. The materials used in this study were Landsat 7 TM satellite imagery acquisition in 2006, 2011 and Landsat 8 OLI in 2016 obtained from USGS to obtain information on land use change and digital topographic map of Solok Regency.

Land use information is required to obtain information and classification processes for the development of land use structures and patterns in the study area. In the process of classification carried out a combination of supervised and unsupervised classifications. The supervised classification is performed after segmentation process. Segmentation is the process of dividing region based on pixel algorithm which then followed by giving the sample based on object and survey result so that segmentation can be used as classification boundary. This process uses training sample such as pattern approach, hue, color, and association with nearest neighbor method and assisted with manual editing [5,7].

Land use change was obtained by comparing land use occurring in actual year to previous observation year. From the results of the analysis will be obtained area, direction and trends of development and change of each type of land use within the period of two points of observations. Field checks are also required as a way to improve accuracy in the classification process. In this research, some geometric correction is done to improve the accuracy of coordinate position and image enhancement to improve visual quality of image data [2,7].

3. Results and discussion

3.1. Remote Sensing Image Analysis and Geographic Information System (GIS)
Landsat image of Solok Regency on 2006, 2011 and 2016 is limited by the administrative boundaries of Solok Regency located on the UTM grid of 47 South zone. Image processing is intended to extract the information contained both spatial and descriptive information. Image recovery process is done through geometric correction caused by position shift to reference coordinate system using ground control point data, the process is called "resampling", while radiometric correction has not done because it has been corrected by the image supplier. Radiometric correction is performed for errors caused by recording time or errors resulting from the sunlight traveling from an object to the camera recorder through the atmospheric medium.

The sharpening of the contrast is done by modifying the image values of each band, in order to obtain clearer information. The image reinforcement process is done by creating a composite image composite for bands 5, 4, 3 for Landsat 7 TM and band 6, 5, 4 for Landsat 8 OLI. Bands are selected based on the
most representative colour discrimination to show the best shape of the object. Improved image contrast (image stretching) is done through histogram alignment (histogram equalization). The largest frequency value of the histogram that has the highest peak can be selected according to the combined combination of its image. Furthermore, from the resulting composite image can be interpreted visually on the monitor screen, so that class division can be detected by the process of classification.

The image classification process uses maximum likelihood technique (maximum likeness). The results of classified imagery in the form of land use consisting of nine types of use. The interpretation of the object for each class according to the characteristics and reflectance graph using the signature comparison module. The results of interpretation of classified imagery is divided into 9 classes as primary forest, secondary forest, paddy field, settlement, mixed plantation, crop field, water bodies, bushes and plantations.

Based on the interpretation result above then ground check and field verification was done in order to get the information according to the field condition [8]. Ground check is the process of matching the result of image classification that has been interpreted with land cover conditions in the field, while field verification is a step to get certainty of objects classified based on secondary data and observation result.

3.2. Land use in 2006, 2011 and 2016

Based on image classification of land use in 2006, 2011 and 2016 can be identified 9 types of land use as primary forest, secondary forest, paddy field, settlement, mixed plantations, crop fields, water bodies, bushes (bushes), and plantations. The following table will explain the area of each land use type (table 1).

| No | Land use          | 2006 Area (ha) | 2006 % | 2011 Area (ha) | 2011 % | 2016 Area (ha) | 2016 % |
|----|-------------------|----------------|--------|----------------|--------|----------------|--------|
| 1  | Primary Forest    | 162,883        | 48.3   | 162,653        | 48.23  | 159,544        | 47.31  |
| 2  | Secondary Forest | 17,207         | 5.1    | 16,088         | 4.77   | 14,679         | 4.35   |
| 3  | Paddy Field      | 45,361         | 13.5   | 45,666         | 13.54  | 45,591         | 13.52  |
| 4  | Settlement       | 3,709          | 1.1    | 3,770          | 1.12   | 3,963          | 1.18   |
| 5  | Mixed Plantations| 70,805         | 21.0   | 71,789         | 21.29  | 76,478         | 22.68  |
| 6  | Crop Fields      | 27,489         | 8.2    | 27,489         | 8.15   | 27,489         | 8.15   |
| 7  | Water Bodies     | 6,690          | 2.0    | 6,690          | 1.98   | 6,690          | 1.98   |
| 8  | bushes           | 2,454          | 0.7    | 2,454          | 0.73   | 2,165          | 0.64   |
| 9  | Plantations      | 620            | 0.2    | 620            | 0.18   | 620            | 0.18   |
|    | Total            | 337,220        | 100    | 337,220        | 100    | 337,220        | 100    |

Based on the table 1 shows that the preliminary data in 2006 was Primary Forest area of 162,883 Ha (48.30%), then Mixed Plantations with an area of 70,805 ha (21%). Five years later in 2011 there was a change where most land use was Primary Forest covering 162,653 Ha (48.23%), then Mixed Plantations with 71,789 ha (21.29%). Then in 2016, the Primary Forest area of 159,544 Ha (47.31%), then Mixed Plantations with an area of 76,478 ha (22.68%). The distribution of each land use type forms a typical pattern of district land use types (rural) where the highest percentage of land use is forest and agricultural land.
3.3. Land use change in 2006 – 2011
The widest land use change is the Secondary Forest change to Mixed Plantations with an area of 747 ha or an area of 64.33% of the total land area change. The total area of land that has been changed is 1.161 ha, and the total unused land is 336.847 ha. The most widespread land use change took place on Secondary Forest land use that turned into Mixed Plantations, followed by a change from Primary Forest to Paddy Field.

Table 2. The distribution of land use change in 2006 - 2011

| Land use                  | Area of Year 2011 (ha) | Total in 2006 |
|---------------------------|------------------------|---------------|
|                           | PF     | SF  | PdF | S   | MP  | CF  | WB  | Bs  | Pl |
| Primary Forest (PF)       | 162,65 | 218 | 13  |     |     |     |     |     |    |
| Secondary Forest (SF)     | 16,08  |     |     |     | 747 |     |     |     |    |
| Paddy Field (PdF)         | 45,66  |     |     | 48  |     |     |     |     |    |
| Settlement (S)            | 3,77   |     |     |     |     |     |     |     |    |
| Mixed Plantations (MP)    | 135    |     | 71,78|    |     |     |     |     |    |
| Crop Fields (CF)          |        |     |     |     |     | 27,48|    |     |    |
| Water Bodies (WB)         |        |     |     |     |     |     | 6,69|    |    |
| Bushes (Bs)               |        |     |     |     |     |     |     | 2,45|    |
| Plantations (Pl)          |        |     |     |     |     |     |     |     | 620|
| Total in 2011             | 162,65 | 16,08| 46,019| 3,832| 72,535| 27,489| 6,690| 2,454| 620|
| Total in 2011             | 338,38 |     |     |     |     |     |     |     |    |
3.4. Land use change in 2011–2016
The widest land use change is the change of Primary Forest to Mixed Plantations with a width of 3.109 ha or an area of 61.21% of the total land area change. The total area of land that has been changed is 5.078 ha, and the total unused land is 334,798 ha. The most extensive land use change occurred on the use of Primary Forest land that changed to Mixed Plantations, followed by a change from Secondary Forest to Mixed Plantations.

| Land use                        | Area of year 2016 (ha) | Total in 2011 |
|---------------------------------|------------------------|---------------|
|                                 | PF   | SF   | PdF | S   | MP | CF | WB | Bs | Pl |          |
| Primary Forest (PF)             | 159,54 |     | 3109 |     |     |   |    |    |    | 162,65   |
| Secondary Forest (SF)           | 14,67  | 1409 |     |     |     |   |    |    |    | 16,08    |
| Paddy Field (PdF)               | 45,59  | 147  | 4   |     |     |   |    |    |    | 45,74    |
| Settlement (S)                  | 3,96  |     |     |     |     | 3,96|    |    |    |          |
| Mixed Plantations (MP)          | 76    | 45   | 76,47 |   | 76,59 |          |
| Crop Fields (CF)                |       |     | 27,48 |     |     | 27,48|    |    |    |          |
| Water Bodies (WB)               |       |     |     |     | 6,69 | 6,69|    |    |    |          |
| Bushes (Bs)                     | 289   |     |     | 2,16 | 2,45 | 620 | 620 |    |    |          |
| Plantations (Pl)                |       |     |     |     |     |     |     |     |     | 338,38   |
| **Total in 2016**               | 159,54 | 14,67 | 45,66 | 4,15 | 81,28 | 27,48 | 6,69 | 2,15 | 620 | 338,38   |

4. Conclusion
There are 9 types of land use available in Solok District. The land uses are Primary Forest, Secondary Forest, Paddy Field, Settlement, Mixed Plantations, Crop Fields, Water Bodies, Bushes, and Plantations. The most widespread land use in Solok District is Primary Forest land use, amounting to 48% of the total area of Solok district. In 2006 to 2011, the most widespread land use change took place on Secondary Forest land use which later became Mixed Plantations. In 2011 to 2016, the most widespread use of land occurred in the use of Primary Forest type of land which later became Mixed Plantations.

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