The critical land in Komering watershed as a result of land use changes from 2000-2016 period

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Abstract. Land use changes in a watershed could affect the ecological system, hydrological system and water quality, meanwhile land use changes study is needed to conduct especially in Komering watershed. Land use is the main factor that determines level of critical land, so the land use changes should correspond with the capability through which degraded land can be controlled. This study aimed to calculate land use/land cover changes from 2000 to 2016 and generate critical land criterions. The objective of the study was to determine the physical and social factors that influence the degree of criticality land in watershed. Physical and social characteristics were measured including land use changes, solum, slopes, outcrop, and land productivity. This study applied supervised classification-maximum likelihood algorithm in ENVI 5.1 imagine to detect land use changes observed in Komering watershed, South Sumatera province, using multispectral satellite data obtained from Landsat 7 and Landsat 8 for the years 2000 to 2016 respectively. Determination of the level of critical land and land use conditions are executed through a spatial approach by utilizing Geographic Information Systems (GIS) and statistical analysis.

1. Introduction
The phenomenon of land-use change is one of the major environmental changes occurring around the world today, including in Indonesia. The determining factors of land use change are the increase in the population which resulted in the need for land is also increasing [1]. According to Verburg [2] land use changes is a complex interaction between structural factors and human behavior associated with technological capabilities, needs, and social interaction. The complex interactions will affect the carrying capacity of the environment. The impact of land use changes will affect the ecology directly for both biodiversity and aquatic ecosystems. The land use such as uncontrolled deforestation, the expansion of agricultural land, and urban development will worsen the condition of the watershed [3]. Watershed conditions are poorly marked by a decline in the quality and availability of water [2], the intensity of flooding is high, reduced groundwater discharge, the extinction of some endangered species, reduced productivity of agricultural land, and an increase critical land [4].

The critical land is soil that function loss for growing plants [5] because the soil loses its fertility [6]. The critical land occurs due to the incompatibility of the soil’s ability to use the land, resulting in soil physical damage, chemical, or biology [7]. Understanding some of the definitions of degraded soils have the same meaning, namely soil loss as a function of production factors and protective factors. The production function characterized the performance of the plants that can be the object of production (agriculture and forestry), or the production of services (comfort and beauty
environmental), while the protection function regarding the protection of soil and hydrology. So, the critical land can be critical in terms of physical land, a critical socio-economic, and critical in terms of hydrology [8]. Land degradation has deteriorated the quality of land and it can be caused by the water erosion, wind erosion, ravines, salt-affected areas, water logging, shifting cultivation, forests degraded and the other special issues [9].

This research is aimed to identify the impact of land use change over 15 years time period at watershed with perspective spatial and temporal. However the specific objectives are (i) to identify and delineate different land use/land cover categories and the pattern of land use change in watershed from 2000 to 2016 (ii) to form criteria of critical land in watershed with combining physical and social factors by using remote sensing data and spatial analysis with GIS, which is reinforced by quantitative analysis. Given the watershed as an ecosystem is an indicator of environmental damage, this study is considered important to do as a preventive measure the incidence of environmental problems that will be caused by human activity in utilizing land.

2. Methods
2.1 Study Area
This study was conducted in Komering watershed from July to September 2016. Komering watershed is one of sub watersheds in Musi basin located on Sumatera island at South Sumatera province, Indonesia. The Komering watershed belongs to three administrative regency of South Sumatera, the first is Ogan Komering Ilir, second is Ogan Komering Ulu Timur, and third is Ogan Komering Ulu Timur. The absolute location of this study is between 103° 34' 12" – 105° 0’ 36” E and 02° 58’ 12" – 04° 59’ 24” S with area coverage of 806,062 Ha. In general, the topography of the watershed is relatively flat in the middle and lower with reaches of slope of between 0-2% and 2-15%. Whereas upper Komering watershed began undulating topography dominated by a slope of between 15-25% with the highest point is 2126 mean sea level. The type of land use in the watershed is dominated by plantation with an area 313,798 ha, or approximately 8.93% of the total area of research (Fig 1).

2.2 Materials
- Satellite data
  Landsat images of path/row 124/62 and 124/63; Landsat 7 ETM for the year 2000, and Landsat 8 OLI for the year 2016. The satellite acquisition date for the images was July to September.
- Raster Data
  Digital Elevation Models Shuttle Radar Topography Mission (DEM SRTM) path-row 57-13 and 58-13
- Vector data
  1. Watershed boundary (Obtained from Musi Watershed Management Agency, “BPDAS Musi” – South sumatera province).
  2. Administrative district boundary of Indonesia (Obtained from Geospasial Information Agency, “BIG”)

![Figure 1. Map of Komering Watershed](image-url)
3. Landuse of South sumatera province (2000 and 2015), obtained from Ministry of Agricultural dan Spatial. [Scale:1:50.000].
4. Landsystem of South sumatera province obtained from Geospasial Information Agency, “BIG”[Scale 1 : 250.000]
   - Tabular Data
     Production of crop (in units of Ton) at South sumatera province in 2015 obtained from Central Bureau of Statistic,
   - Software
     ENVI 5.1, Arc GIS 10.1, and SPSS 17.

2.3 Data Analysis
   - Landuse classification
     Classification of land use was conducted using supervised classification in ENVI 5.1 software. There are 180 traning samples were used to detect the type of land use/land cover in Komering Watershead. The classification of land use/land cover in Komering watershed was produced in six classes. These included; forest, water, settlement, agriculture, bare-land and plantation. Assessment of classification accuracy of 2000 and 2016 images was carried out to determine the quality of information derived from the data. For the accuracy assessment of land use/land cover maps extracted from satellite images, stratified random method was used to represent different land cover classes of the area. The accuracy assessment was carried out using 100 points, based on visual interpretation from high resolution images. In addition, a nonparametric Kappa test was also performed to measure the extent of classification accuracy as it not only accounts for diagonal elements but for all the elements in the confusion matrix [10]. Post-classification change detection technique, performed in ArcGIS 10 was employed by the study.
   - Critical Land Classification
     In this study critical land classification in watershed developed based on physical dan social factors such as: percentage of land use changes, slope, solum, outcrop, and productivity. In order to generate samples, the study area was divided into 2.5 km x 2.5 km grid and as many as 1.432 boxes. The number of sample points (n) is determined based on population-sample table that is 10% of total grid (N) used [5]. Samples will be processed using the SPSS software.

2.4 Research Procedure

Figure 2. Critical land classification process
3. Result And Discussions

3.1 Landuse Change

The classified land-use map of Komering watershed of years 2000 and 2016 is given in Fig 3 and Fig 4. The achieved overall classification accuracies were 82.96% and overall kappa statistics were 0.7523 respectively for the classification images. The accuracy assessment reporting requires the overall classification accuracy more than 70% which were successfully achieved in the present research [11].

The cross-tabulation matrices (Table 1) show the nature of change of different land cover classes or in other words the shift in the land cover classes. According to the information revealed by classification results, the plantation showed 4.46% increase from 2000 to 2016. Out of the 300,256 ha that was plantation area in 2000, 299,999 ha was still plantation area in 2016 but 256 ha was converted to settlement, and then to agriculture and forest. At the same time the increased of plantation, from 2000 to 2016, was mainly from agriculture (13,270 ha). Forest also increase from 201,662 ha in 2000 to 201,812 ha in 2016, indicating a 0.07% of forest regrowth. Another type of LULC agricultural land, have been increased from 300,256 ha in 2000 to 313,798 ha in 2016, representing an 4.32% increase. Bare land out of 3,054 ha in 2000 lost area mainly to plantation (25.26%), agriculture, forest and retained 2,088 ha of total in 2016. Bare land decreased rapidly (by 46.23%) between 2000 and 2016. Water decreased from 21,816 ha in 2000 to 21,814 in 2016, indicating an 0.01% decrease.

| LU/LC type 2000 | 2016 | Water | Forest | Agriculture | Plantation | Settlement | Bare land | Total |
|----------------|------|-------|--------|-------------|------------|-----------|-----------|-------|
| Water          | 21,813 |       |        |             |            |           |           | 21,816|
| Forest         | 201,661|       |        |             |            |           |           | 201,662|
| Agriculture    | 236,347| 13,270| 232    | 299,999     | 256        | 29,421    | 3,054     | 806,062|
| Plantation     | 236,556| 13,270| 232    | 299,999     | 256        | 29,421    | 3,054     | 806,062|
| Settlement     | 236,556| 13,270| 232    | 299,999     | 256        | 29,421    | 3,054     | 806,062|
| Bare land      | 150    | 208   | 527    | 79          | 2,088      |           |           | 3,054 |
| Total          | 21,814 | 201,812| 236,556| 313,798    | 29,992     | 2,088     | 806,062   |       |

(Source: Data processing, 2016)
3.2 Critical Land Classification

The classes of critical land in watershed perform using cluster analysis by method Average Linkage (Between Groups) with Euclidean distance interval [12]. The results of an analysis from five variables used, shown that there are three classes of critical land like; critical, potential critical, and not critical. Preparation of critical land criteria based on the assumption that each population expected to have a homogenous covariance [1]. Box's M test results against factors that meet the homogeneity of covariance (P>0.05) obtained five factors that is: forest, water, settlement, agriculture, bare-land and plantation. These factors are analyzed stepwise discriminant method. Method stepwise secrete factors each detected collinear (multicollinearity), with sub methods mahalanobis distance to identify outliers (Sitorus et al., 2011). The coefficient obtained in a linear function is used to determine the factors that have biggest contribution to the difference between classes. so it can be used to perform weighted factors selected [13] [1].

Discriminant analysis results shown there are three variables that contribute to make three classes of critical land, namely: outcrop (X1); slope (X2), and productivity (X3). The contribution of each variable is obtained from the coefficients contained in the function generated by discriminant analysis (D = -4.70 + 0.189X1 - 0.138 X2 - X3 0.04). Based on the test results significant discriminant function has amounted to 57.30% ability to explain variation among classes of critical land. Besides this discriminant function has eigenvalue 1,340 or >1. This indicates that the discriminant function was valid [13] [14].

Based on the coefficient of the factors that contributed most to the difference between the classes is weighted each factor namely: outcrop (48%), slope (27%), and the productivity of the land (25%). Based on the weighting, critical land in the Komering watershed was influenced by the percentage of outcrop with values of 48%, while the rest influenced by slope of 27% and land productivity by the value of the effect of 25%. According to Ministry of Agrarian and Spatial Planning (2016) outcrop is one of the factors that caused a critical land. The main problems in regions that have an outcrop are serious soil erosion, mining activities in stony/rocky areas, landslides and it will cause critical land [9]. Furthermore, based on the analysis and previous description, criteria acquired critical land and indicators as shown in Table 2. By adding up the value (score) of the indicator, the cumulative amount of each class as shown in Table 3 was derived. The result of statistical analysis by weighting of each variable is presented in spatial data with overlay method.
The result of weighting main factors that influence critical land was shown in a critical land map, as illustrated in Fig. 4. Most of the study area was dominated by non critical area by 95.66% (771,079 ha), while area of critical detected by 0.6% (4,836 ha). Based on the land use/land cover in the Komering Watershed, forest have a most tendency as a potential critical land by 60.74% (18,990 ha) of the total area critical potential, and then plantation by 32.28% (10,090 ha) of the total area critical potential Fig. 5.

| Variables | Classification of Critical Land |
|-----------|---------------------------------|
|           | Not Critical | Critical Potential | Critical |
| Outcrop   | <10%         | 10-20%             | >20%     |
|           | (weighted 48%) |
| Slope     | 0-20%        | 20-40%             | >40%     |
|           | (weighted 27%) |
| Land Productivity | >4 Ton/ Ha | 2-4 Ton/ Ha | <2 Ton/ Ha |
|           | (weighted 25%) |

4. Conclusions
Based on the results obtained by employment of GIS, Remote Sensing, and statistical analysis to achieve the specific research objectives, it is concluded that the increase in plantation areas from 37.25% to 38.93% is closed related with decrease in agriculture areas from 31.00% to 29.35%. There are three classes of critical land and the factors that contributed most to the difference between the classes namely; outcrop (48%), slope (27%), and the productivity (25%). The result of overlay
analysis from the variables shown that study area was dominated by non critical area by 95.66% (771,079 ha), while area of critical detected by 0.6 % (4,836 ha). Based on the type of land use/ land cover, forest have a most tendency as a potential critical land by 60.74% of the total area critical potential.

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