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# Analysis of remote sensing data for identification of land closure and determine erosion hazard level in Mandikaleng Watershed, Banjar Regency, South Kalimantan Province

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**Key words:** Analysis, Land cover, Erosion.

**Abstract**

Banjar Regency is an area that has extensive critical land compared to several districts in South Kalimantan. This can be seen from the results of the critical land inventory in BPDAS Barito, there is a critical area of 112.57 hectares. One area that needs attention is the mandikaleng catchment area (DTA). The mandikaleng DTA has an area of 606.52 Ha, which has quite complex problems as seen from the decrease in land productivity and is included in the first priority priority catchment area, namely the Martapura watershed. Identifying land cover, analyzing the rate of erosion, determining the level of erosion hazard in the Mandikaleng DTA, Karang Intan District, Banjar Regency, making recommendations for soil conservation based on erosion hazard levels to control erosion that occurs in the Mandikaleng catchment, Karang intan district, Banjar Regency. The results of land cover object segmentation classification show that the classification level with scale level 30 values, and merge level 90 is able to separate the object of classification of land cover properly.

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**Introduction**

Watershed is a dynamic ecosystem that connects upstream and downstream. The dynamics of changes in land use can cause damage to watershed ecosystems, such as drought, decreased land productivity, and disruption of hydrological watersheds, both on site, and off site (Halim, 2014), one of the problems with adequate watershed complex is erosion, because it can cause land damage. Erosion is an eroded process and the transport of soil layers by natural water media.

Erosion is one of the serious problems in a watershed ecosystem, this is caused by land use change. This is because there is no vegetation that can hold rainwater directly which can increase the amount of surface flow (Yanti *et al.*, 2017). The amount of rain kinetic energy can be reduced by the role of vegetation which can inhibit the rate of rainwater. Land cover factors can affect erosion in terms of known vegetation density based on land cover information. (Lathifah & Yunianto, 2013).

Banjar Regency is an area that has extensive critical land compared to several districts in South Kalimantan. This can be seen from the results of the critical land inventory in BPDAS Barito, there is a critical area of 112.57 hectares. One area that needs attention is the mandikaleng catchment area (DTA). Mandikaleng DTA has an area of 606.52 Ha, which has quite complex problems that can be seen from the decrease in land productivity and is included in the first priority Priority Watershed, namely the Martapura Watershed (BPDAS Barito, 2014). The Mandikaleng catchment also acts as one of the rainwater suppliers whose outlets enter the right riam river as a supplier of the main water needs in the cities of Martapura and Banjarbaru.

To predict erosion, empirical methods are usually used. In this study erosion prediction used the Universal Soil Loos Equation (USLE) method, because this prediction model would be very effective when integrating with Geographic Information Systems (GIS), because it can provide fast and accurate calculation information by stacking all parameters to predict land lost (Rusnam, 2013).

One parameter in determining erosion is land cover. This information can be extracted from remote sensing data in the form of satellite images, using the digital classification method, namely the classification of object-based segmentation. Classification with this method provides quite accurate accuracy during spatial and spectral object extraction processes, when compared to pixel-based classifications that only use spectral information for object recognition in the field. Spatial resolution produced from satellite imagery is very limited according to pixel size, to avoid the limitations of spatial information produced by satellite imagery used as information for land cover information, each sampling in the field is assisted by drones to see the detail of each land cover, which is produced while also functioning as a ground check tool for land cover in the field.

Remote Sensing Data (PJ) has several advantages in terms of helping researchers to know the picture of the earth's surface with the actual appearance and location of objects, wide area coverage, and permanent image properties, so researchers will know the condition of the region precisely and quickly. Although of these several advantages, PJ data also has weaknesses in terms of this research. One of them is caused by the presence of mixed pixels which is a problem in classification using the "hard" classification method such as object-based classification / object segmentation used in this study, where one pixel can be classified into one dominant object, whereas in one pixel it is possible to have more from one object.

This is caused by the spectral reflection produced by the soil is stronger and very dominant than the spectral reflections produced by vegetation.

Soil Conservation is one way of managing land by repairing soil, maintaining and increasing land use in accordance with its designation. Soil conservation aims to increase soil productivity, and reduce soil erosion. (Meylina *et al.*, 2015).

The PJ and SIG data is very useful in managing spatial information regarding the condition of the earth's surface in this case land cover. Therefore, in further developments, the technology tends to be integrated in order to increase the efficiency of the acquisition and the accuracy of the results of the mapping, as input in the process of developing the land information system. Research carried out through the integration of PJ data, GIS, and with the help of drones to analyze land cover to determine the level of erosion hazards that have not yet been published in several studies. Based on the background above, we need a study of "Land Closure Analysis to Determine Erosion Hazard Levels in Mandikaleng Watersheds", to get the extent of Erosion Hazard Levels (TBE) that occur during land cover in the Mandikaleng catchment area. This research can be used in determining the direction of land rehabilitation and soil conservation in the area which is the object of research as a benchmark in soil conservation technical recommendations so that watershed management can run well. The purpose of this research is to. identify Land Closure in the Mandikaleng catchment, Karang Intan sub-district, Banjar district, analyze the magnitude of the erosion rate that occurred in the Mandikaleng catchment, Karang Intan sub-district, Banjar regency, determine the Erosion Hazard Level (TBE) at Mandikaleng catchment, Karang Intan sub-district, Banjar district, making recommendations for soil conservation based on erosion hazard level (TBE) to control erosion that occurs in the Mandikaleng catchment, Karang intan sub-district, Banjar Regency. The benefits of this research are expected to be able to provide input in the control of erosion in the Mandikaleng DTA, so that the priority of soil conservation actions can run optimally according to their designation.

## Material and methods

Materials

The materials used in this study are soil samples which include the physical properties of soil at the research site, plastic bags for taking soil samples, Area Drone markings, for aerial photo markers at each land cover, spatial data required by the RBI Earth Map (RBI) Scale 1: 50,000, to support the research location, map of soil type 1: 250,000 scale from Bogor Soil Research Center, Spatial slope data derived from Digital Elevation Model (DEM) data, Shuttle Radar Topography Mission (SRTM) spatial resolution of 30 M, Sentinel 2-A image, 2017 acquisition in October 2017.

The equipment used is. Dji Phantom 4 Pro drone, for aerial photography at the research location, android handphone, for setting up drones in real time, GPS Receiver Garmin 64 S, for taking research sample points, digital cameras, for documentation of research activities, ground drill and sample rings, meter, crowbar, machete, and knife, raffia rope, for making stand density plots, stationery and Tally Sheet. Spatial Data Analysis Software used as Arc Gis 10.6.1 Software is used for spatial analysis, Envi 5.1 software is used for raster data processing, Global Mapper v15 software is used to create catchment boundaries.

Methods

*Large Erosion Calculation (A)*

Estimation of erosion as one of the bases for determining Erosion Hazard Levels (TBE), can be calculated by the USLE equation developed by (Wischmeier & Smith, 1978), as follows:

A = R. K. L. S. C. P. Fk

Information:

A = Number of eroded soils (ton / ha / year)

R = Average annual rainfall erosivity factor (mj.cm/ha/hours / year)

K = soil erodibility factor (ton ha.hour / ha / mj.cm)

L = Slope length factor (m)

S = Slope factor (%)

C = Plant management factors

P = soil conservation factor

Fk = Ruslan Correction Factor = 0.61 (Ruslan, 1992).

*Rainy Erosion (R)*

The value of rain erosivity factor (R) is calculated using the Bols formula (1978), namely:

$$R_m = 6{,}119 (Rain)_m^{1{,}21} x (Days)_m^{-0{,}47} x (MaxP)_m^{0{,}53}$$

Information:

Rm = Average monthly rainfall Erosion (EI30 (mj.cm/ha/hours/month)

(Rain) m = Monthly average rainfall (cm)

(Days) m = Number of rainy days monthly average (days)

(MaxP) m = Maximum daily rainfall (cm) and,

$$R = \sum_{m=1}^{12} (R_m)$$

Description: R = Average annual rainfall erosion

Rm = amount for 12 months.

*Erodibility of Land (K)*

Erodibility of the soil shows the sensitivity of a soil type to erosion. This K factor value is determined by analyzing the physical properties of the soil which includes texture, structure, permeability and organic matter content. Organic material content is included with the approach number proposed by Arsyad (2010), which is as shown in Table 1 below.

**Table 1.** Class percentage of organic matter content.

| Class | Content of organic matter | Erodibility level |
|---|---|---|
| 0 | < 1 | Sangat rendah |
| 1 | > 1 – 2 | Rendah |
| 2 | > 2,1 – 3 | Sedang |
| 3 | > 3,1 – 5 | Tinggi |
| 4 | > 5 | Sangat tinggi |

Source: (Arsyad, 2010).

Soil structure is a small lump of grains of land, this occurs because the grains of sand, dust and clay are bound to one another by one adhesive such as organic matter. The results of the analysis of soil structure types can be determined (score). The classification of determining soil structure score values can be seen in Table 2.

**Table 2.** Land Structure Values.

| Ground Structure Class (Size Diameter) | Value |
|---|---|
| Granular Very Fine (<1 mm) | 1 |
| Fine Granular (1 to 2 mm) | 2 |
| Granular Medium to Rough (2 to 10 mm) | 3 |
| Cube / Clump, Clumped Angled, Plate, Massive | 4 |

Source: (Arsyad, 2010).

Assessment of soil permeability was carried out in the laboratory through soil samples taken using sample rings so that the soil was not spared. Soil permeability ratings are presented in Table 3 below.

**Table 3.** Permeability assessment of soil profile.

| No | Type of permeability | Speed CM / hour | Value P |
|---|---|---|---|
| 1. | Fast | >25,4 | 1 |
| 2. | Medium to fast | 12.7 to 25.4 | 2 |
| 3. | Is being | 6.3 to 12.7 | 3 |
| 4. | Slow to moderate | 2.0 to 6.3 | 4 |
| 5. | Slow | 0.5 to 2.0 | 5 |
| 6. | Very slow | <0.5 | 6 |

Source: (Arsyad, 2010).

Soil samples taken in the field were analyzed to determine the erodibility value (K). Furthermore, the K value is determined using the equation made by Wischmeier, *et al.*, 1971 in (Arsyad, 2010), namely:

100 K = 1,292 [2,1M1,14 (10-4). (12-a) + 3,25 (b-2) + 2,5 (c-3)].

Information:

K = soil accessibility

M = % percentage of dust +% very fine sand x (100 -% clay)

a = Percentage of organic matter (%)

b = Land structure value and c = soil permeability class

*Slope and Slope Length (LS)*

The length and slope factors found in the Mandikaleng catchment (LS) are calculated based on Digital Elevation Model (RSTM) data with 30 m Spatial Resolution, using the equations proposed by (Cooley, 2015) as follows:

LS = (Flow acc x (cell size) / 22.1) 0.4 ((Sin (slope in degrees x 0.01745) / 0.09) 1.4) x 1.4

Where: flow acc = flow accumulation

So the value of the length index and slope of the slope is the result of multiplication between the value of the factor of the slope length (L) with the slope factor value (S)

*Crop Management (Factor C)*

The value of crop management factor (C) is the ratio of the erosion ratio of the land planted with a type of plant with erosion from the control plot.

The C factor used is based on the results of several researchers cited in (Arsyad, 2010).

*Soil Conservation (P Factor)*

The value of soil conservation factor (P) is obtained from dividing the soil loss from the treated land (P) with soil loss from the standard plot, taken from several researchers cited in (Arsyad, 2010), which can be seen in Appendix 4.

*Determination of Erosion Hazard Level (TBE)*

The Erosion Hazard Level is obtained from the calculation of the Erosion Rate A = Ton / Ha / Yr then grouped into the available Erosion Hazard Class Tables. The analysis results from the Erosion Hazard Level are linked to the soil solum class table, so that there are several classes of Erosion Hazard Levels (TBE), which details Erosion Hazard Levels (TBE) can be seen in Table 4.

**Table 4.** Erosion Hazard Level (TBE) based on Soil Solum Thickness and Erosion Hazard Amount (Maximum Erosion Amount, A).

| Solum Soil (cm) | Erosion Hazard Class (EHC) | | | | |
|---|---|---|---|---|---|
| | I | II | III | IV | V |
| | Erosi Maksimum (A) - (ton/ha/tahun) | | | | |
| | < 15 | 15 - 60 | 60 – 180 | 180 - 480 | > 480 |
| | Erosion Hazard Level (EHL) | | | | |
| In (> 90) | 0 – SR | I – R | II – S | III – B | IV – SB |
| Is being > 60 - 90 | I – R | II – S | III – B | IV – SB | IV – SB |
| Shallow 30-60 | II – S | III – B | IV – SB | IV – SB | IV – SB |
| Very shallow <30 | III – B | IV – SB | IV – SB | IV – SB | IV – SB |

Source: Ministry of Forestry, (2013).

Information:

0 - SR = very light,

I - R = light,

II - S = medium,

III - B = weight IV - SB = very heavy.

*Direction of Forest and Land Rehabilitation (RHL)*

The criteria used in determining the direction of forest and land rehabilitation based on the results of the Erosion Hazard Level produced with the coverage of priority areas included in the category of heavy and very heavy categories.

## Results and discussion

*Identification of Land Closure*

Based on the results of the classification found in the Mandikaleng catchment with a total area of 606.52 hectares, the results of 4 land cover classes were obtained, namely Open Land, Rarely Dense Forest, Medium Density Forest, and High Density Forest. The Mandikaleng DTA is an area covered by Rarely Density Forest with an area of approximately 184.65 Ha or around 30.45%, after that it is seen by Open Land with an area of 176.52 Ha with a contribution of 29.10%, Medium Density Forest with an area of 158, 67 Ha or 26.16% and High Density Forest which forms an association with an area of 86.67 Ha with a percentage of 14.29%. The types of land choices available in the Mandikaleng catchment can be seen in Table 5.

**Table 5.** Classification of Land Closure in the Mandikaleng DTA.

| No | Landscape | Large (Ha) | Percentage (%) |
|---|---|---|---|
| 1. | Open field | 176,52 | 29,10 |
| 2. | Rarely Density Forest | 184,65 | 30,45 |
| 3. | Medium Density Forest | 158,67 | 26,16 |
| 4. | High Density Forest | 86,67 | 14,29 |
| Total | | 606,52 | 100,00 |

*The Amount of Erosion Rate in Mandikaleng Catchment Area*

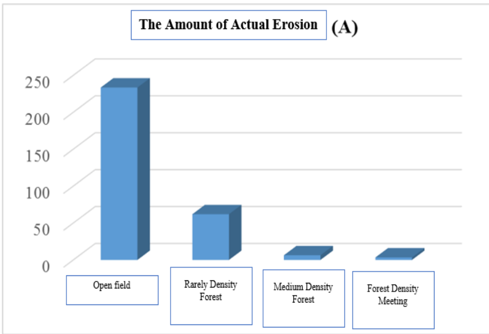


**Fig. 1.** Graph of the Erosion Rate Actual on Each Land Closure.

Based on Fig. 1 graph the actual erosion rate at each land cover above can be seen the difference in average erosion rate values found in each land cover class, caused by the level of vegetation on the soil, the smallest erosion rate seen in the class of high density forest land cover, p. This is because trees that form asoasi have a high canopy density, so that it can cover the entire surface of the soil, as well as dense understorey. Where the lower plants can hold rain water so that it does not directly fall to the surface of the ground and eventually can reduce surface flow. A small surface flow can give time to the water to seep into the soil, so that the runoff volume can be reduced. This is in accordance with the opinion of Meylina *et al* (2015) that each understorey is a surface flow inhibitor that can reduce the rate of erosion.

*Danger Level of Erosion*

Erosion Hazard Level (EHL) is the estimated maximum soil loss compared to the thickness of the soil solum in each unit of land. If the techniques of crop management and soil conservation do not change. The value (EHL) of each Land Closure can be seen in Table 6.

**Table 6.** EHL values at each Land Closure in the Mandikaleng Catchment Area.

| No | Land Closure | Large (Ha) | Depth | | Danger of Erosion | | EHL |
|---|---|---|---|---|---|---|---|
| | | | (cm) | Class | Ton/ha/year | Class | |
| 1. | Open field | 176,52 | 60-90 | Medium | 233,44 | IV-SB | Very Weight |
| 2. | Rarely Density Forest | 184,65 | 60-90 | Medium | 61,87 | III-B | Weight |
| 3. | Medium Density Forest | 158,67 | 60-90 | Medium | 6,29 | I-R | Floaty |
| 4. | Forest Density Meeting | 86,67 | 60-90 | Medium | 3,32 | I-R | Floaty |

Source: Results of primary data analysis in 2018.

Based on Table 6. The calculation results for erosion hazard levels indicate that from 4 types of land cover in the field it is known that open land cover has very heavy erosion values, followed by shrub land cover with heavy erosion, then medium and high density forests have mild erosion value. By obtaining erosion values at each land cover based on the total area of the study site. Then it is known that 40.45% of the area with a mild erosion hazard with an area of 245.34ha, followed by 30.45% of the area with a severe erosion hazard with an area of 184.65 ha, then 29.10% of the area with a level the danger of erosion is very heavy with an area of 176.52ha. Vegetation has an important role in erosion control, vegetated land is generally easier to absorb water, because litter is able to withstand raindrops, and root outcrops, and soil organic matter can increase soil porosity and stabilize soil structure. Vegetation also plays a role in storing ground water and causing a high rate of infiltration of rainwater. (Sarminah, *et al*., 2018). Closure of land with forest vegetation will also provide a more significant impact on the rate of erosion and sedimentary processes than other factors, such as climate, characteristic soil and topography. This is in accordance with the opinion of Badaruddin (2015).

*Recommendations for Soil Conservation Measures in the Mandikaleng Catchment Area*

Based on the results of the evaluation of erosion hazard levels in the Mandikaleng catchment, to be able to reduce the level of erosion hazard, recommendations for soil conservation measures can be determined, namely in areas of severe and very heavy TBE with land cover in the form of open land and rare forest densities. The directives that can be recommended are vegetative and mechanical approaches. The following are recommendations for soil conservation measures in accordance with the direction of forest and land rehabilitation presented in Table 7, as follows.

**Table 7.** Recommendations for Soil Conservation in the Mandikaleng Catchment Area.

| No | Land Closure | EHL | Soil Conservation Recommendations | Large (Ha) |
|---|---|---|---|---|
| 1 | Open field | Very heavy | Reforestation and Traditional Terrace Production | 176,52 |
| 2 | Rarely Density Forest | Weight | Reforestation and planting according to contours | 184,65 |
| 3 | Medium Density Forest | Floaty | Left naturally | 158,67 |
| 4 | High Density Forest | Floaty | Left naturally | 86,67 |

Source: Primary data analysis in 2018.

Seen Based on Table 7. Recommendations for soil conservation are aimed at the class of land cover which has a heavy and very heavy erosion hazard level. In the results of land cover analysis, open land given recommendations for soil conservation measures covering an area of 176.52ha, sparse density forest covering 184.65ha, while for land cover for rare and high density forests no land conservation measures were taken or left naturally.

The results of the study (Rusdi & Karim, 2013), stated that in the application of vegetative and mechanical conservation measures, it must be adapted to the appropriate land use directives in order to maintain its sustainability. On land with severe erosion hazard levels can be done by developing annual crop farming (plantation crops, and industrial plants, while on land with very heavy erosion hazard levels are not used for agricultural land, but rather directed towards conservation measures planting plants that cover the soil continuously such as reforestation, reforestation is generally used by plants that can prevent erosion and have a long life, and preferably from types of perennials such as timber and types of MPTS which have high economic value from wood products and derivatives that can be produced from wood that is.

## Conclusion

Based on the results of the research and analysis above, a number of research conclusions can be drawn as follows:

1. The land cover object segmentation classification results show that the classification level with scale level 30 values, and merge level 90 is able to separate the object of land cover classification properly.
2. The magnitude of Erosion Rate at each land cover, which is open land of 233.44 Ton/Ha/Yr, Rare Density Forest is 61.87 Tons/Ha/Yr, Medium Density Forest is 6.29 Tons/Ha/Yr, and High Density Forest of 3.32 Tons/Ha/Yr.
3. Erosion Hazard Levels in the Mandikaleng catchment are classified based on the land cover class, which is in the class of open land cover very heavy TBE of 29.10% (176.52 Ha), Density Forest Rarely TBE Weight of 30.45% (184.65 Ha), and Medium Density Forest and Lightweight TBE Meeting of 40.45% (245.34 Ha).
4. The recommended soil conservation technique for open land class land cover types, namely reforestation and traditional terrace making, recommended soil conservation techniques for rare density forest classes, namely reforestation and contour planting, while for medium density forest classes and high density forests left naturally/without the need for soil conservation measures because the erosion produced is mild.

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