# Land Erodibility and Land Use Directions in Krueng Seulimum Watershed Aceh Province

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**Abstract**

**Purpose** – The purpose of this research is to to determine the value of land erodibility in Krueng Seulimum watershed.

**Design/Methodology/Approach** – This research apply survey method and field measurement that begins with making land unit map.

**Findings** – The results showed that Krueng Seulimum watershed consisted of 22 units of land (LU). The value of land erodibility in secondary forest land use is low, i.e., 0.13–0.19 (LU 13 and 22), the value of land erodibility in grazing lands land use is medium, i.e., 0.31–0.32 (LU 9 and 11 ), the value of land erodibility in scrub lands land use is rather high, i.e., 0.33–0.35 (LU 2, 6, 12, 15, and 19) and the value of land erodibility in dry land agriculture land use is medium – rather high, i.e., 0.28–0.35 (LU 3, 7, 10, and 16).

**Research Limitations/Implications** – The land use directions for scrub lands is for cocoa-based mixed crops, such as cocoa monoculture, cocoa + areca nut, and cocoa +banana.

**Practical Implications** – The use of dry land agriculture is maintained for land use coupled with agrotechnology action that is guludan terrace plus mulsa application.

**Originality/Value** – Most of the soil in the Krueng Seulimum watershed has very low soil fertility level that affects nutrient availability plant. These characteristics should be considered in the direction of land use in the Krueng Seulimum watershed.

**Keywords** Watershed, land use, land erodibility, agrotechnology

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## 1. Introduction

The intensity of land use change in the Krueng Seulimum Watershed (DAS) area is increasing. Krueng Seulimum watershed with an area of 25,444.35 hectares has undergone extensive forest functions. In 1977, the forest area in Krueng Seulimum watershed was still around 16,179 ha (70.86%), in 1987 decreased to 11,129.10 ha (48.75%), and in 2002 the forest area remained 9,032,40 ha (39.56%) (Wahyuzar, 2005). While in 2011, the forest area in Krueng Seulimum watershed live 7,000.01 ha (27.51%) (Akbar, 2013).



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The transfer of forest functions that occur in the Krueng Seulimum watershed is a change to agricultural land, and this will have an impact on the erosion. Rainfall is one of the causes of erosion, where rainfall power will erode the surface of the soil and this will destroy the aggregate of the soil. Aggregates of soil that have been destroyed and released will be transported by a surface stream somewhere deposition occurs. The whole process, namely the destruction and release of aggregate soils, the transport of soil particles, and the deposition of soil particles is called soil erosion. This is seen with the high erosion resulting in low productivity of land in the upstream area indicated by the low production of cocoa is 271–450 kg (Disbunhut Aceh, 2008).

One of the factors affecting erosion is the factor of soil erodibility. The greater the soil erodibility value of soil, the more susceptible the soil is to erosion. Soil intensity is highly dependent on two soil characteristics, that is, soil aggregate stability and infiltration capacity (Hardjowigeno, 2010).

The soil aggregate stability is strongly influenced by soil structure normally determined by soil organic matter, percentage of sand fraction, dust, and clay (Wiersum, 1979; Sukartaatmadja 1993). Furthermore, Greenland (Hardjoamidjojo, 1965; Sukartaatmadja, 1993) suggests that the soil with high clay content and organic material has stable soil aggregates, because it has strong bonds between its colloids. An important criterion in estimating the sensitivity of soils to erosion is the clay ratio, that is, the ratio between the percentage of sand and dust with the percentage of clay (Bouyoucos, 1935 in Hardjoamidjojo and Sukartaatmadja, 1993).

This study aims to: (1) calculate the value of soil erodibility in each unit of land in the Krueng Seulimum watershed and (2) determine the direction of land use in the Krueng Seulimum watershed.

## 2. Methods

This research was conducted in Krueng Seulimum watershed which is administratively located in the sub-districts of Seulimum and Lembah Seulawah in Aceh Besar regency within 50 km from the provincial capital.

The materials used includes soil type maps, topographic maps, earth maps, land use maps, rainfall data, demographic data, and chemicals for laboratory analysis. Among the equipments used are surveying equipments, equipments for the analysis of soil properties in the field and in the laboratory, stationery, work maps, GPS, GIS software, a digital camera, and a computer.

This study used a survey method consisting of four phases, namely, the preparation, preliminary survey, main survey, and data analysis as well as result presentation. Land erodibility value was calculated using the formula Wischmeier and Smith (1978):

$$100\mathrm{K} = \{1.292\Big(2.1\,\mathrm{M}^{1.44}(10^{-4})(12-a) + 3.25(b-2) + 2.5(c-3)\Big)\}$$

where K is the soil erodibility; M, the soil texture grade (% silt + % dust) −100 ( % clay); $a$, the percentage of organic matter; $b$, the soil structure; $c$, the soil permeability.

## 3. Results and Discussion

### *3.1 Land unit*

The result of overlapping of land type map, slope map, and land use map, Krueng Seulimum watershed with 25,444.35 ha consists of 24 units of land (LU). Furthermore, the intensive observation of this research is on the use of secondary forest land (LU 13 and 22), the use of grazing land (LU 9 and 11), the use of scrubland (LU 2, 6, 12, 15, and 19), and the dry land farmland (LU 3, 7, 10 and 16). More details of land units in the Krueng Seulimum watershed can be seen in Table 1.

### *3.2 Land use*

Land use in Krueng Seulimum watershed consists of secondary forest area of 7,001,1 ha, 5,988,15 ha of scrub, 5,631,19 ha of dry land agriculture, 5,033,27 ha of grazing area, 1,455,15 ha of rice field and width of residence 335,58. Land use for dryland farming which is commonly found in Krueng Seulimum watershed is cocoa-based farming without treatment of soil and water conservation measures (Table 2).

### *3.3 Land characteristics in krueng seulimum watershed*

Changes in land use in the Krueng Seulimum watershed mainly from the use of forest land into agricultural land cause many problems, including land subsidence, erosion, flora and fauna extinction, floods, drought and even global environmental changes. This problem grew heavily over time as the area of the forest being converted into another business land. Lal (1994 in Banuwa 2008) reports the relationship between erosion with deforestation, that is, the erosion of a small catchment area in French Guiana increases dramatically after deforestation. Observations made on small-scale plots also show that natural vegetation clearance has led to an increase in the runoff coefficient of 25–100 times, while erosion also increased to more than 10-fold (Roose, 1986).

| | | | Large | |
|---|---|---|---|---|
| LU | Slope | Land Use Type | Ha | % |
| 1 | 0–8% | Grazing Land | 847,68 | 3.33 |
| 2 | 0–8% | Scrub Land | 972,13 | 3.82 |
| 3 | 0–8% | Dry Land Agriculture | 889,54 | 3.50 |
| 4 | 0–8% | Secondary Forest | 398,79 | 1.57 |
| 5 | 0–3% | Grazing Land | 2,716.15 | 10.67 |
| 6 | 0–3% | Scrub Land | 4,301.19 | 16.90 |
| 7 | 0–3% | Dry Land Agriculture | 2,671.05 | 10.50 |
| 8 | 0–8% | Secondary Forest | 2,502.72 | 9.84 |
| 9 | 0–3% | Grazing Land | 834,81 | 3.28 |
| 10 | 0–3% | Dry Land Agriculture | 1,687.23 | 6.63 |
| 11 | 8–15% | Grazing Land | 166,14 | 0.65 |
| 12 | 8–15% | Scrub Land | 174,09 | 0.68 |
| 13 | 8–15% | Secondary Forest | 419,87 | 1.65 |
| 14 | 8–15% | Grazing Land | 546,47 | 2.15 |
| 15 | 8–15% | Scrub Land | 267,87 | 1.05 |
| 16 | 8–15% | Dry Land Agriculture | 295,94 | 1.16 |
| 17 | 8–15% | Secondary Forest | 1,559.24 | 6.13 |
| 18 | 15–25% | Secondary Forest | 285,84 | 1.12 |
| 19 | 15–25% | Scrub Land | 192,59 | 0.76 |
| 20 | 15–25% | Secondary Forest | 550,12 | 2.16 |
| 21 | 15–25% | Secondary Forest | 498,09 | 1.96 |
| 22 | 25–40% | Secondary Forest | 876,06 | 3.44 |
| 23–24 | 0–3% | Settlement and Rice field | 1,790.73 | 7.04 |
| Total | | | 25,444.35 | 100.00 |

**Table 1.** Land Units in the Krueng Seulimum Watershed

*Source:* Primary data and digital data analysis (2011 and 2016)

Based on the characteristics of each unit of land (LU 1–22) and the soil properties assessment criteria issued by the Soil Research Center (1983). Most of the soil in the Krueng Seulimum watershed has very low soil fertility level that affects nutrient availability plant. These characteristics should be considered in the direction of land use in the Krueng Seulimum watershed. For that purpose in the development of sustainable agriculture in Krueng watershed, the minimum action of agrotechnology needs to be designed land erodibility.

### *3.4 Land erodibility*

Land erodibility is the soil sensitivity to erosion, the higher the erodibility of a soil the easier it becomes eroded Arsyad (2010) states that the land erodibility is affected by soil texture, soil structure, organic matter, and permeability. Furthermore, Asdak (2005) adds that land erodibility factors indicate soil particle resistance to exfoliation and transport of soil particles by the presence of rainwater kinetic energy.

Soil properties to note are soil properties that affect sensitivity to erosion, that is, soil texture, shape and soil structure, infiltration capacity, soil permeability, and organic matter content.

The results of determining the value of land erodibility on 13 selected land units show that land erodibility values range from 0.19 (low) to 0.35 (rather high). The lowest erodibility value was found in the use of forest land with K values of 0.13–0.19 (LU 13 and 22), erodibility was being encountered on dryland farmland with K values of 0.28–0.31 (LU 3, 7, 10, and 16), and slightly higher erodibility values were found in the use of scrubland with K values of 0.33–0.35 (LU 2, 6, 12, 15, and 19).

The higher the land erodibility the more eroded soil, this will in turn affect the development of the land form. Thus, land erodibility is one part of the causal factor of erosion also contributes to the development of land form. Conversely, the level of land erodibility is also not separated from the geomorphological processes that affect the formation and development of the soil.

The land use directive for shrubs is for cocoa-based cocoa farming, cocoa monoculture, cocoa + betel, and banana + cocoa, while the use of dryland farming land is maintained for dryland farming use plus agrotechnology action by making terrace of bund and mulching.

The improvement efforts *that* need to be done by giving organic materials, mulching, and application of soil and water conservation techniques. So that the organic matter content in the soil does not decrease due to the decomposition process of mineralization, it is advisable when tillage the addition of organic matter absolutely must be given every year, because without giving organic material can cause chemical degradation, physical, and biological soil, which can damage aggregate soil and cause compaction soil.

**Table 2.**
Land Use in Krueng Seulimum Watershed
*Source*: Baplan Dephut (2011) and Field Analysis (2016)

| No | Types of Land Use | Area ha | Area % |
|---|---|---|---|
| 1 | Settlement | 335.58 | 1.32 |
| 2 | Rice field | 1,455.15 | 5.72 |
| 3 | Grazing lands | 5,033.27 | 19.78 |
| 4 | Scrub lands | 5,988.15 | 23.53 |
| 5 | Dry Land agriculture | 5,631.19 | 22.13 |
| 6 | Secondary forest | 7,001.01 | 27.51 |
| | Total | 25,444.35 | 100.00 |

Another benefit of mulch is to suppress rainwater energy, so that the soil remains stable and protected from the destruction process. (Suwardjo, 1981) also suggests that mulching is very effective at reducing surface flow and erosion by up to 25%. The application of 4–5 tons of hay mulch can reduce very low erosion on the slopes of 15% (Lal, 1976).

Abdurachman and Sutono (2002) also added that the role of mulch in suppressing the rate of erosion is largely determined by mulch material, the percentage of ground cover, the thickness of the mulch layer, and the durability of the mulch against decomposition. Lal (1994) also added that mulching of crop residues of 4–6 tons $ha^{-1}$ was able to increase infiltration rate, as well as decrease surface flow velocity and erosion at a still negligible level.

## 4. Conclusion

Based on the research results can be drawn some conclusions follows:

(1) Land erodibility in some land uses varies greatly, secondary forest land use is low, i.e., 0.13–0.19 (SL 13 and 22), the use of pasture land is moderate, i.e., 0.31–0.32 (SL 9 and 11), the use of scrubland is rather high, i.e., 0.33–0.35 (SL 2, 6, 12, 15, and 19), and the use of dryland agriculture is moderately high, i.e., 0.28–0.35 (SL 3, 7, 10, and 16).

(2) The land use directive for shrubs is for cocoa-based mixed crops, such as cocoa monoculture, cocoa + areca nut, and banana + cocoa, while the use of dryland farmland is maintained for dryland farming use plus agrotechnology action by making terrace of bund and mulching.

(3) Improvement efforts that need to be done by giving organic materials, mulching, and application of soil and water conservation techniques

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