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Study of Soil Erodibility Under the Potato Farming System in the Upstream Lembang Watershed

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Abstract: Farmers cultivate potatoes intensively in the upper Lembang watershed, i.e. cultivate the land every planting season. The soil management system does not apply soil conservation methods, so it is suspected that there has been a decline in soil fertility. The purpose of this study was to examine the soil properties of potato farming in several land forms. The method used is the land survey method. Soil sampling was done by purposive random sampling and descriptive. Soil samples taken were disturbed soil samples for analysis of soil physical properties (texture, bulk density, total pore space, permeability) while direct measurements in the field were effective soil depth and infiltration rate. Meanwhile, undisturbed soil samples were used to analyze the chemical properties of C-organic soil. Soil analysis was carried out in the laboratory of the Department of Soil, Faculty of Agriculture, Andalas University. To determine the soil characteristics of the landform is to analyze the soil parameters using Minitab 17 software. The results showed that the value of soil erodibility in the production center area is strongly influenced by c-organic variables, dust, bulk density, total pore space, fine sand fraction, fraction clay and soil permeability. The value of soil erodibility includes low to moderate criteria. It was concluded that the soil condition was still quite good.

Keywords: Potato Farming, Soil Erodibility, Soil Degradation, Conservation

1. Introduction

Intensive land use in agricultural land, causes changes in soil properties, such as soil resistance to the destructive power of rain kinetic energy or also known as rain erosivity energy. Soil resistance to the destructive power of raindrop energy greatly influences soil erosion or erosion of the soil surface, causing the soil surface layer, especially the tillage layer to become thinner. This is because erosion carries parts of the soil from one place to another, especially on lower slopes. According to the soil loss equation, the rate of soil erosion can be more influenced by rainfall characteristics, land slope and slope length, land cover, and management than soil properties. However, some soils erode more easily than others despite the similarity of the factors of the soils. This difference, influenced by the properties of the soil itself, is called soil erodibility [1]. Soil erodibility is strongly influenced by soil properties such as: soil texture (very fine sand, silt, and clay), soil structure, organic matter content, and permeability [2].

The shape of the land cultivated by farmers now is wavy, so this causes a variety of soil properties. The cause is the effect of erosion on land with sloping slopes and accumulation of erosion material on lower or flatter slopes transported by surface runoff. The soil is easily eroded by surface runoff due to its height. Varied landforms and intensive use will cause soil erodibility values to also vary. Land that has a gentler slope will cause the erodibility of the soil to be higher. This will causethe amount of fine soil particles carried by surface runoff [3]. Therefore, soil erodibility is the sensitivity of the soil to erosion, the higher the erodibility value of a soil, the easier the soil is to erode.

Soil erodibility is influenced by soil texture, soil structure, organic matter, and permeability [4]. Soil erodibility factor shows the resistance of soil particles to peeling and transport of soil particles by the kinetic energy of rainwater [5]. Furthermore, it was found that the average soil loss was negatively correlated with clay content but positively correlated with very fine sand and silt plus very fine sand content [6]. Soil physical and chemical properties are often influenced by organic matter content, by building aggregations, soil organic matter affects soil erodibility.

This study aims to study the dominant factors that affect the value of soil erodibility in potato production centers in the upstream sub-watershed of Lembang.

2. Materials and Methods

2.1. Research Sites

This research was conducted in a potato production center located in the upstream of the Lembang sub-watershed. More precisely in the villages of Kampung Batu Dalam and Batu Bajanjang with a geographical position of 100°42'0" E - 100°44'0"E and 1°0'0"S-1°0'2"S (Figure 1), Solok district, West Sumatra, Indonesia.

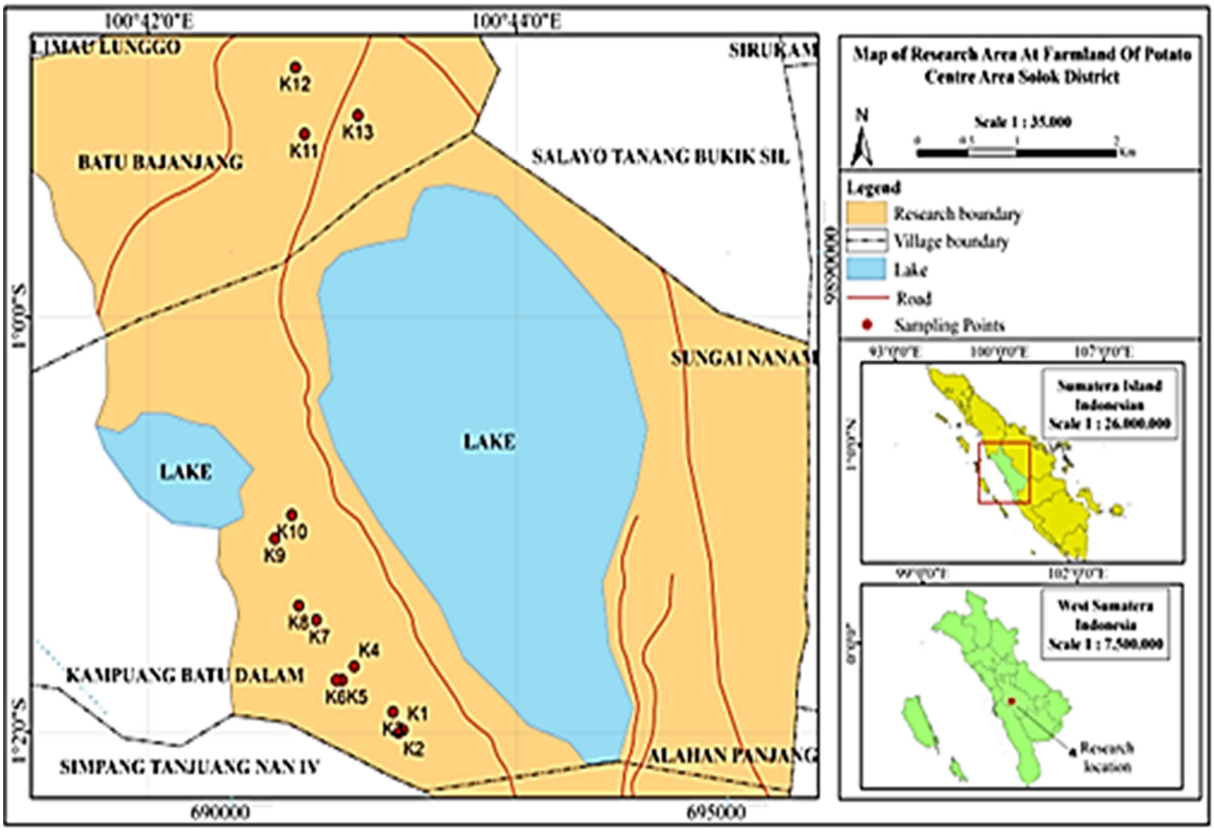

Figure 1. Map the research location.

2.2. Research Methods

2.2.1. Soil Sampling

This research was conducted by means of a field survey in the potato production center area in the Upper Lembang sub-watershed. Samples were taken based on five groups of land units (Table 1). Based on the soil map, the potato production center area is dominated by two soil orders, namely Andisol and Inseptisol (Table 1). The study was conducted on V groups of farmers based on the physiography of the land, the groups are; groups I, II, III, IV and V. Group I is flat, II is slightly sloping, III is sloping, IV is flat, V is sloping. Therefore, it is the center of potato production. Soil samples taken are undisturbed soil samples with a ring sample for analysis of soil physical properties. For analysis of soil chemical properties, disturbed soil samples were taken using a Belgian soil drill.

Figure 2. Photos of potato fields in the research location.

Table 1. Groups, soil types and sampling points.

Location	Type of soil	Soil sampling	plan type
I	Andisol	3	Potatoes
II	Andisol	2	Potatoes
III	Inceptisol	4	Potatoes
IV	Inceptisol	2	Potatoes
V	Inceptisol	2	Potatoes

2.2.2. Soil Analysis in the Laboratory

Soil samples from the field were analyzed in the soil laboratory, for analysis of soil physical properties for variables; texture and permeability, bulk density, total pore space. The variable soil chemical properties analyzed were organic matter.

2.2.3. Soil Variable Calculation

(i). Soil Erodibility

Soil variable data from the results of laboratory analysis is used to calculate the value of soil erodibility using the soil erodibility formula [1]. Soil Erodibility (K) The calculation, soil erodibility is obtained from the results of field observations and laboratory analysis. The soil properties tested were organic matter content, texture, structure, soil permeability, which were then calculated using the equation 1:

$$K=\frac{2.173(2.1\, M^{1.14}(10^{-4})(12-a)+3.25(b-2)+2.5(c-3)}{100}$$

description: M = value of (% dust +% very fine sand) (100% clay);

a = organic matter (% C organic x 1.724);

b = soil structure value;

c = value of permeability.

Table 2. Criteria for soil erodibility value.

No	Class	Criteria
1	Very low	0.00 – 0.10
2	Low	0.11 – 0.20
3	Currently	0.21 – 0.32
4	A bit high	0.33 – 0.43
5	Tall	0.44 – 0.55
6	Very high	0.56 – 0.64

The erodibility value obtained from the calculation of the soil properties in each land unit is compared with the criteria for the erodibility value of the soil (Table 2).

(ii). Principle Component Analysis

Analysis of the main components of the soil from the erodibility characteristics of the soil. Principal Component Analysis (PCA), is used to: determine what factors most influence the value of soil erodibility. The researcher also uses this method to determine the main factors that affect the value by using PC with an eigenvalue of more than 1 as the independent variable. Therefore, this value is highly correlated with the independent value in PC, [7]. Researchers used Minitab 17 to analyze data variables.

3. Results and Discussion

3.1. Soil Properties

From the soil analysis in the laboratory, soil variables were obtained to calculate the soil erodibility value (Table 2). The results of the analysis of the physical and chemical properties of the soil at the research site (Table 2) indicate that the soil in this area is dominated by soil with a dusty loam texture and crumb soil structure, so that potatoes are very suitable to grow in this area. The soil is quite crumbly and plants can grow and develop well. In this soil condition, potato roots and tubers can develop optimally, so that potato yields are optimal. Soils that have loose properties are usually easily dispersed by the kinetic energy of rainfall.

3.2. Soil Erodibility

Based on the variable data of soil properties (Table 3), the soil erodibility value was calculated using the formula. From the calculation results of the soil erodibility value, the soil erodibility value is obtained as shown in Table 4. This soil erodibility value is compared with the criterion value (Table 2). It turns out that the value of soil erodibility in this potato production center area is dominated by very low and low criteria. This means that the soil in the potato production center area has a fairly good ability to withstand the threat of soil erosion. This is due to the high influence of organic matter on the soil so that it can become a cemented agent for soil fractions. Further research [6]. in Iran also stated that organic matter by coating soil particles and creating a water-repellent layer that prevents soil release and keeps soil particles flocculated, thereby reducing erodibility and soil erosion. In addition, the factor seen from the relationship between organic matter and erodibility has a negative correlation, meaning that increasing organic matter will reduce the value of soil erodibility.

Further research [8] showed that soil organic matter and clay content were the main factors affecting soil anti-erodibility in the Loess Plateau and the percentage of stable aggregate to water was the best indicator.

Table 3. Soil properties from the location of the potato production center area in the upstream sub-watershed of Lembang.

Location of The sampling	C-org %	Sand %	Dust %	Clay %	Bv g/cm^3	Permeability (cm/hour)	Total Pore %
1	6.94	6.1	68.86	24.84	0.53	24.79	80
2	7.08	12.87	70.1	16.7	0.54	2.86	76.02
3	4.45	20.25	57.87	18.26	0.7	7.31	73.58
4	6.99	4.29	62.94	26.1	0.66	7.54	75.09
5	8.31	5	62.48	22.23	0.65	26.18	75.47
6	9.26	5.78	57.83	33.25	0.85	1.95	67.92
7	7.56	5.68	61.52	23.9	0.46	0.35	82.64

Location of The sampling	C-org %	Sand %	Dust %	Clay %	Bv g/cm^3	Permeability (cm/hour)	Total Pore %
8	9.9	5.68	51.51	23.9	0.65	12.51	75.47
9	10.18	7.67	66,48	8.02	0.78	4.44	70.57
10	9.4	13.79	67.44	15,17	0.56	21.85	78.87
11	11.59	6.62	51.13	24.21	0.97	2.14	63.4
12	11.74	5.26	44.73	42.07	0.92	10.96	65.28
13	8.62	6.75	47.38	17.92	0.91	21	65.66

Table 4. *Soil properties and soil erodibility values in the potato production center area in the upstream Lembang sub-watershed.*

Location sampling	fine sand %	Dust %	Clay %	a	b	c	M	K
1	6.1	68.86	24.84	6.94	3	1	5634.0	0.15 r
2	12.87	70.1	16.7	7.08	2	3	6911.4	0.13 r
3	20.25	57.87	18.26	4.45	2	2	6385.5	0.19 r
4	4.29	62.94	26.1	6.99	2	2	4968.3	0.12 r
5	5	62.48	22.23	8.31	3	1	5247.9	0.12 r
6	5.78	57.83	33.25	9.26	2	4	4246.0	0.09 SR
7	5.68	61.52	23.9	7.56	2	5	5113.9	0.15 r
8	5.68	51.51	23.9	9.9	3	1	4352.2	0.07 SR
9	7.67	66,48	8.02	10.18	2	3	6820.3	0.05 SR
10	13.79	67.44	15,17	9.4	3	1	6890.7	0.09 SR
11	6.62	51.13	24.21	11.59	2	3	4376.9	0.01 SR
12	5.26	44.73	42.07	11.74	3	1	2895.9	0.02 SR
13	6.75	47.38	17.92	8.62	3	1	4443.0	0.11 r

Description: K = erodibility, M = value of (% dust +% very fine sand) (100 -% clay) a = organic matter (% C organic x 1.724).
b = soil structure value c = permeability value, SR = very low, r = low.

Table 5. *The eigenvalues from the analysis of soil variables with PCA.*

Eigenvalue	4,7864	1,2779	1,1122	0,9514	0,4367	0,3426	0,0749	0,0109	0,0070
Proportion	0,532	0,142	0,124	0,106	0,049	0,038	0,008	0,001	0,001
Cumulative	0,532	0,674	0,797	0,903	0,952	0,990	0,998	0,999	1,000

Table 6. *The loading matrix value from analysis of soil biophysical properties.*

Variable	PC1	PC2	PC3	PC4	PC5	PC6	PC7	PC8	PC9
Location	-0,375	0,098	-0,356	0,086	0,512	-0,267	0,605	-0,038	0,123
K	0,401	0,057	0,265	0,317	0,040	-0,351	0,286	0,503	-0,454
C-org	-0,395	-0,174	-0,301	-0,273	0,099	0,308	-0,167	0,501	-0,515
Sand	0,213	0,670	-0,034	0,205	0,326	0,594	-0,029	0,004	-0,047
Dust	0,366	-0,064	-0,264	-0,384	-0,407	0,311	0,618	-0,007	-0,001
Clay	-0,209	-0,425	0,634	0,122	0,194	0,461	0,323	-0,029	0,048
Bv	-0,402	0,280	0,107	0,185	-0,416	-0,032	0,163	-0,462	-0,548
Permebility	0,066	-0,376	-0,461	0,748	-0,181	0,216	-0,037	-0,011	0,045
Total Pore	0,392	-0,323	-0,123	-0,140	0,459	-0,024	-0,098	-0,530	-0,454

Principle Component Analysis (PCA).

3.3. Eigenvalues

The determining factor based on the eigenvalue greater than 1 is retained, but if it is less than 1 then the factor is excluded from the model. An eigen value shows the contribution of the factor to the variance of all original variables. Only factors with variance greater than 1 are included in the model. Factors with a variance of less than 1 are not good because the original variables have been standardized, which means the average is 0 and the variance is 1 (Table 5).

3.4. Main Component

To determine which soil properties are more dominant, the soil erodibility factor is determined based on the results of the principle component analysis (PCA) and can be seen in table 6. From the PCA analysis, there are three main components that determine the diversity of soil erodibility, namely PC1, PC2 and PC3. Table 6 shows that there are three factors (PC) having eigenvalues greater than 1, namely PC1, PC2 and PC3. Of the three factors, it is able to explain the variation of the total data that more influences the value of soil erodibility in the potato production center area in the upstream Lembang sub-watershed. From the extract of many data variables, PC1 with an eigen value of 4.78 gives the proportion of influence of 53.2 percent. Then PC2 with an eigen value of 1.27 gives a proportion of 14.2 percent, and PC3 with an eigen value of 1, 11 contributed a proportion of 12.4 percent. These three components cumulatively contribute to explaining the diversity of the total data by 79.7 percent. This means that these three components are representative for all variations that affect the value of soil erodibility in the potato production center area. The first factor (PC1) is a variable of soil properties, namely c-organic, and dust. The second factor (PC2) is sand, and clay. While the third factor (PC3) is the rate of permeability. His previous research [9]. This means that these three components are representative for all variations that affect the value of soil erodibility in the potato production center area. The first factor (PC1) is a variable of soil properties, namely c-organic, and dust. The second factor (PC2) is sand, and clay. While the third factor (PC3) is the rate of permeability. His previous research [9]. This means that these three components are representative for all variations that affect the value of soil erodibility in the potato production center area. The first factor (PC1) is a variable of soil properties, namely c-organic, and dust. The second factor (PC2) is sand, and clay. While the third factor (PC3) is the rate of permeability. His previous research [9]. stated otherwise, sand content has a negative relationship with erodibility and sediment load. Because the mass of the sand particles is greater, runoff cannot transport them. On the other hand, the presence of sand particles in the soil causes an increase in macro pores, water infiltration, and consequently a decrease in susceptibility to erosion. Furthermore soil erosion is also strongly influenced by the characteristics of the soil surface because it is influenced by the tumbling system and the physicochemical properties of the soil [10]. Plants on the soil surface greatly affect the stability of soil aggregates, and soil infiltration properties. Further research [11] showed that, the root factor is very important in providing a binding effect and increasing soil strength, thereby reducing soil erodibility.

4. Conclusion

Based on the results of the study, several conclusions can be drawn;

1) That the resistance of the soil to the erosion of rain erosion is strongly influenced by several variables of soil properties, namely c-organic, fine sand, dust, clay and soil permeability.
2) The value of soil erodibility in the potato production center area is still in very low to low criteria. This means that the soil in this area is not easily damaged by the erosive energy of rain.
3) The value of soil erodibility that is already good and
4) More resistant to rainwater damage needs to be maintained by increasing the organic matter content with the rest of the harvest.
5) Maintain soil resilience in the upstream area of the river and reduce erosion and sedimentation that enters the river body.

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