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Assessment of Soil Damage for Biomass Production in Slope Area Used as Agricultural Land in Tanggetada District, Kolaka Regency

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Abstract

This study aimed to assess the soil degradation level for biomass production in sloping areas used as agricultural land. This research was conducted in Tanggetada District, Kolaka Regency. This research was conducted using a field survey method with a slope class approach which is used as agricultural land with a slope of 8-15%, 15-25%, 25-45%, and > 45%. The results of the study show that the status of soil damage in sloped areas used as agricultural land in Tanggetada District, Kolaka Regency, for slope classes 8-15%, 15-25%, and 25-45% included in the lightly damaged category while slope classes >45% included in the moderately damaged category. The limiting factors for soil damage status at this location are surface rock, microbial count, bulk density, permeability, and redox

Keywords: soil damage, slope, agricultural land

A. Introduction

Soil is the most crucial component in an ecosystem that functions as a place to grow and can store water and nutrients that plants need. The utilization of land for the development of crops is adjusted to its capabilities. Land use not following its designation will damage soil, especially biomass. Soil damage for biomass production is a change like the soil that exceeds the standard criteria for soil damage caused by management actions that are not environmentally sound.

Over time, the increase in population growth has consequences for converting agricultural land into residential, industrial, infrastructure, and other uses. The increase in population growth also impacts increasing the need for food to meet the needs of life. On the other hand, agricultural land has been dramatically reduced, so people are forced to use land unsuitable for agricultural lands, such as land with steep slopes to grow crops.

The area of Tanggetada District is 44,165 Ha, with an area of land used for agriculture of 13,504.51 Ha. The types of plants cultivated are crops (horticultural food crops and plantation crops (BPS, 2021). Based on the interpretation of land use maps and topographic land maps, Farmers in Tanggetada Subdistrict used farmers as agricultural land with slope classes of 8-15%, 15-25%, 25-45%, and >45% covering an area of 7,302.81 Ha. Using land with steep slopes as agricultural land will cause soil damage for agricultural purposes. Biomass production in a sloping area used as agricultural land in Tanggetada District, Kolaka Regency.

B. Literature Review

1. Soil Biomass

Biomass is organic material derived from plants and animals composed of carbon (C), hydrogen (H), and oxygen (O) atoms. Biomass also includes gases and liquids from non-fossil materials and the degradation of organic matter. Biomass is formed from the interaction of carbon dioxide ($CO2_{)}$, air, water, soil, and sunlight (Basu, 2010). Biomass is an environmentally friendly energy source whose carbon source comes from $CO2_{in}$ the air. Combustion of biomass produces the same amount of $CO2_{as}$ is absorbed by the photosynthesis process (Reed and Das, 1988).

2. Slope

The slope of the slope is a specific height difference in the relief that exists in a landform. The land's slope shows the area's character that must be considered in the direction of land use. Each region's land slope is different but generally can be classified into several groups (Sinery, Rudolf, Hermanus, Samsul dan Devi, 2019). According to Gunawan (2011), the land slope class is classified into five types.

a. Mountainous with a slope of more than 45% (greater than 24°)
b. Hilly with a slope of 25-45% or 14°-24°
c. Wavy with a slope of 15-25% or 8°-14°
d. Sloping with a slope of 8-15% or 5-8°
e. Flat with a slope of 0-8% or 0-5°

The slope of the slope is very influential in the process of weathering and soil development, washing, and transport of soil. Soil erosion by water on sloping areas also causes the soil to erode and be transported, ultimately leaving less fertile soil so that soil and plant productivity decreases (Septianugraha and Abraham, 2014).

3. Soil Damage

Soil damage is a process or phenomenon of a decrease in the capacity of the soil to support life with the loss or decline of the function of the soil, both its function as a source of plant nutrients and its function as a matrix where plant roots are anchored and where water is stored. The process of soil damage is a process or phenomenon of a decrease in the ability of the soil to support life at this time or in the future caused by human activities (Roy, 2012). The land is a resource that is the mainstay in the socio-economic activities of the community, especially in developing countries. However, land resources are not sustainable resources. Land resources have changed due to natural processes and human activities. Changes due to natural processes are caused by changes in the earth's surface due to geomorphology. The ongoing geomorphological process will have a direct or indirect impact on the earth's surface's physical condition. The geomorphological process will result in a decrease in the quality and carrying capacity of the land, which in turn will cause land degradation.

Meanwhile, land degradation caused by human activities occurs due to the use of the environment by humans who ignore environmental balance. Land degradation is the loss or reduction of the potential use of land to support life. The loss or change in appearance causes it not to be replaced by others (Siregar, 2010).

C. Methology

1. Research Location

This research was conducted in March 2022. The study was located in Tanggetada District, Kolaka Regency, Southeast Sulawesi Province, and the sample analysis was carried out at the Analytical Laboratory of Halu Oleo University, Kendari.

2. Research procedure

This research was conducted using a field survey method with a slope class approach which is used as agricultural land with a slope of 8-15%, 15-25%, 25-45%, and >45%, identify the characteristics of the land.

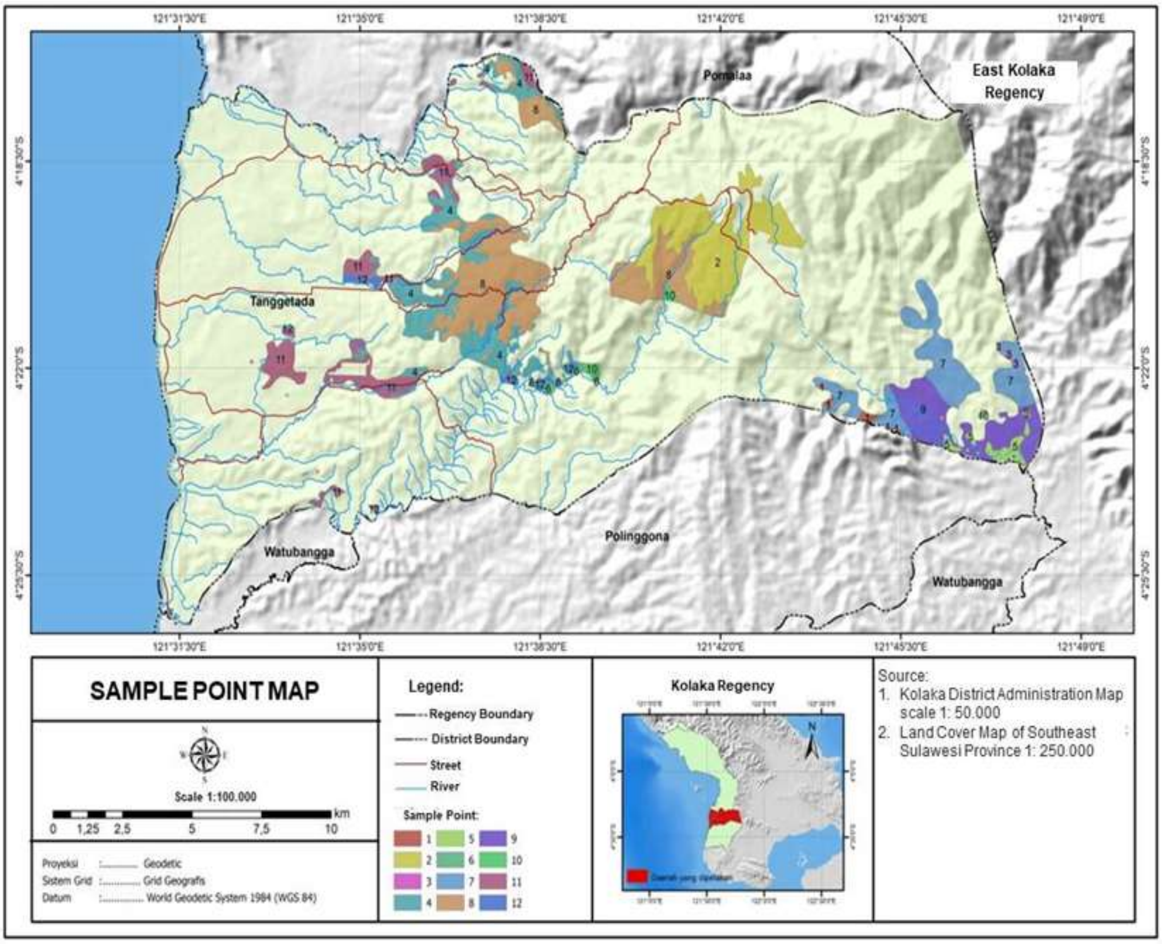

Figure 1. Map of Sample Points

Table 1. Description of Sample Points for Each Slope Class

Slope	Sample	Land Use	Area (Ha)
>45%	1	Dryland farming	33.30
	2	Mixed dry land farming	985.59
		Total	1018.89
15-25%	3	Dryland farming	11.10
	4	Mixed dry land farming	964.90
	5	Dryland farming	110.89
	6	Kebun Campuran	50.12
		Total	1137.00
25-45%	7	Dryland farming	734.21
	8	Mixed dry land farming	1487.00
	9	Dryland farming	569.61
	10	Mixed dry land farming	40.70
		Total	2831.53
8-15%	11	Mixed dry land farming	595.86
	12	Mixed dry land farming	75.80
		Total	671.66

3. Data analysis

Determine standard criteria for soil

Damage Evaluation of soil damage at the research site based on Government Regulation No. 150 of 2000 concerning Control of Soil Damage for Biomass Production Procedures for Measurement of Standard Criteria for Soil Damage for Biomass Production

Table 2. Soil Damage Standard Criteria

No.	Parameters	Critical threshold
1	Thickness	< 20 Cm
2	Surface rock	> 40%
3	Fraction composition	< 18% Colloid, > 80% quartz sand
4	Density	> 1,4 g/cm^3
5	Total porosity	<30 ; >70 %
6	Permeability	<0,7 >8 cm.jam^{-1}
7	pH (H2O) 1:2.5	< 4,5 ; >8,5
8	Electrical Conductivity	> 4,0 mS. cm^{-1}
9	Redox	< 200 mV
10	Microbial Count	<10^{2}cfu/g Soil

Source: Government Regulation No. 150 of 2000

Determination of soil damage status for biomass production

- ***Matching method***

Soil damage identification is carried out by the matching method, namely comparing the results of measurements of each parameter in the field and laboratory with the critical threshold determined in Government Regulation No. 150 of 2000. Matching is carried out at each sample point. Or point of view. Steps to determine the status of soil damage:

1. I calculated the relative frequency (%) of each parameter of soil damage.
2. Giving a score for each parameter based on its relative frequency value
3. Summarizing the score for each parameter of the soil damage criteria
4. Determining the status of soil damage based on the sum of the scores

- ***Scoring Method***

Method *scoring* is carried out by considering the relative frequency of soil classified as damaged in one land unit and then used to determine the category of soil damage status.

Table 3. Soil Damage Status Based on the Relative Frequency of Each Parameter

Relative Frequency of Damaged Soil (%)	Score	Soil Damage Status
0-10	0	Not Damaged
11-25	1	Damaged
26-50	2	Medium Damaged
51-75	3	Severely Damaged
6-100	4	Very heavily damaged

Source: Minister of Environment Regulation No. 7 of 2006

Table 4. Soil Damage Unit Based on Accumulated Value Soil Damage Score

Relative Frequency of Damaged Soil (%)	Class Soil Damage Status	Accumulated Value Soil Damage Score Land Dry
0-10	Not Damaged	0
11-25	Light Damage	1-14
26-50	Moderate Damage	15-24
51-75	Severe Damage	25-34
6-100	Very heavily damaged	35-40

Source: Ministry of Environment Regulation No. 7 of 2006

D. Result and Discussion

The causes of soil damage are caused by the nature of the soil and human activities that cause the land to be disturbed/damaged and unable to function anymore. Activities that use land and other natural resources uncontrollably can cause damage to the soil for biomass production, thereby reducing the quality and function of the soil, which in turn can threaten the survival of humans and other living things.

The analysis of the status of soil damage at the research site is based on the Regulation of the Minister of the Environment No. 7 of 2006 concerning Procedures for Measuring Standard Criteria for Soil Damage for Biomass Production, as well as data that affect the calculation of soil damage analysis. Analysis of soil damage status for each level of the slope is described in the following table:

Table 5. Soil Damage Status on Slope Class 8-15%

No.	Parameter	Sampel		FR	Skor
		1	2		
1	Solum thickness	120	96	0	0
2	Surface rock	6,25	6,25	0	0
3	Fraction composition				
	- Sand	66,12	51,6	0	0
	- Clay	5,76	26,32	0	0
4	Bulk density	1,57	1,27	50	2
5	Total porosity	27,94	50,74	50	2
6	Degree of water	3,21	2,66	0	0
7	Permeability	6,21	6,54	0	0
8	pH (H2O) 1:2.5	0,03	0,026	0	0
9	Redox	231	202	0	0
10	Total Microbes	137	100	0	0
Total Score					4
Soil Damage Status Slightly					Damaged
Limiting Factors					Bulk density and Soil Porosity

Based on observational data on soil damage used as agricultural land on slopes of 8-15%, including mild damage with inhibiting factors for bulk density and soil porosity. The ideal for biomass production is below 1.4 g/cm^3. One factor that affects plant growth is the high and low density of the soil. The denser the soil, the more difficult it will be for plant growth (Haridjaja, O., Hidayat, Y., dan Maryamah, L.S., 2010).

Table 6. Soil Damage Status on slope class 15-25%

No.	Parameter	Sampel				FR	Skor
		1	2	3	4		
1	Solum thickness	114	110	87	109	0	0
2	Surface rock	12.5	6.25	6.25	6.25	0	0
3	Fraction composition						
	- Sand	40.38	27.89	71.64	64.82	0	0
	- Clay	12.41	13.61	7.63	14.04	0	0
4	Bulk density	1.78	1.52	1.37	1.12	50	2
5	Total porosity	23.25	42.71	44.35	57.6	25	1
6	Degree of water	2.31	2.11	0.14	0.21	50	2
7	permeability (Permeability)	6.54	7.1	6.72	5.92	0	0
8	pH (H2O) 1:2.5	0.035	0.018	0.036	0.01	0	0
9	Redox	172	191	213	199	75	3
10	Total Microbes	102	156	112	122	0	0
	Total Score						8
	Soil Damage Status Slightly						Damaged
	Limiting Factors						bulk density, porosity, redox

The status of soil damage on slopes of 15-25% is categorized as lightly damaged with inhibiting factors bulk density, porosity, and redox. The more sloping soil is, the more intensive erosion occurs, which causes loss of organic matter and nutrients in that location. The low content of organic matter will affect the density, soil porosity, redox, and the number of microbes in the soil. The density of the soil is an indication of the density of the soil. The denser the soil, the higher the weight of its contents, which means it is more difficult to pass water or penetrate plant roots. (Hardjowigeno, 1993). Hanafiah (2012) states that porosity reflects the level of ease of the soil to pass water flow (permeability) or the speed of water flow to pass through the soil mass (percolation).

Table 7. Status of soil damage on slope class 25-45%

No.	Parameter	Sampel				FR	Skor
		1	2	3	4		
1	Solum thickness	88	85	83	76	0	0
2	Surface rock	6.25	6.25	6.25	6.25	0	0
3	Fraction composition						
	- Sand	40.98	28.41	69.89	22.34	0	0
	- Clay	11.11	31.75	23.76	33.52	0	0
4	Bulk density	1.44	1.56	1.32	1.45	75	3
5	Total porosity	45.65	41.96	49.89	45.25	0	0
6	Degree of water	0.87	2.3	0.75	0.32	25	1
7	Permeability	6.2	6.22	6.57	6.31	0	0
8	pH (H2O) 1:2.5	0.068	0.002	0.035	0.03	0	0
9	Redox	229	223	212	209	0	0
10	Total Microbes	139	107	105	167	0	0
	Total Score						4
	Soil Damage Status Slightly						Light damage
	Limiting Factors						Bulk density and permeability

The status of soil damage on slopes of 25-45% is included in the category of light damage with inhibiting factors for bulk density and permeability. The value of density and permeability have implications for the ability of plant roots to reach water in the soil. This occurs due to intensive land use activities without any processing in the tillage layer, thus increasing soil density and bulk density. Arifin (2010) states that continuous intensive soil management without resting the soil and without adding organic matter damages the soil structure. This results in a decrease in soil permeability.

The increase in soil density is due to agricultural activities, which also affects the increase in soil density. Overall, the survey results show that the value of soil fill density increases with increasing soil depth, both in locations that produce high production and locations with low production. This follows Hardjowigeno (2003) statement that the higher bulk density causes the soil density to increase, and aeration and drainage are disturbed.

Table 8. Status of soil damage on slope class >45%

No.	Parameter	Sampel		FR	Skor
		1	2		
1	Solum thickness	54	73	0	0
2	Surface rock	50	50	100	4
3	Fraction composition				
	- Sand	22.62	21.85	0	0
	- Clay	14.88	37.22	0	0
4	Bulk density	1.56	1.42	100	4
5	Total porosity	22.11	29.67	100	4
6	Degree of water	0.15	0.13	100	4
7	permeability (Permeability)	5.31	6.11	0	0
8	pH (H2O) 1:2.5	0.025	0.032	0	0
9	Redox	178	169	100	4
10	Total Microbes	93	86	100	4
Total Score					24
Soil Damage Status Slightly					Moderate damage
Limiting Factors					Surface rock, bulk density, permeability,

redox, and total microbes

Soil damage status on slopes >45% has moderate damage status with inhibiting factors: surface rock, bulk density, permeability, redox, and Total microbes. Soil with a slope of > 45% will experience high erosion, affecting the soil properties that affect biomass production. Andrian, Supriadi dan Purba M., (2014) and Kasmawati, Hasanah U., dan Rahman, A., (2016) stated that the more sloping the slope of the soil, the greater the water flow velocity on the surface so that the erosion of parts of the soil is more significant. Dela & Mardiatno (2012) stated that the flow velocity would increase with the more excellent slope value, and the carrying capacity of the crushed soil particles would be higher so that the erosion process would be even greater. One of the inhibiting factors at this location is the number of microbes. Microbes are one of the critical factors in the soil ecosystem because they can affect the cycle and availability of nutrients for plants and the stability of soil structure. Biomass formation is also influenced by many other factors, namely temperature and humidity (Joergensen, R.G., P.C Brookes and D.S Jenkinson, 1990). The ideal microbial count for biomass production is more significant than 10^2cfu/g soil. Soil with high micro-organisms will accelerate the process of biomass decomposition that plants can utilize.

E. Conclusion

Based on the results of the assessment of the status of soil damage on sloped areas used as agricultural land in Tanggetada District, Kolaka Regency, for the slope class 8-15%, 15-25%, and 25-45%, including the category of mild damage while the slope class >45% belongs to the damaged category. Currently. The limiting factors for soil damage status at this location are surface rock, number of microbes, bulk density, permeability, and redox.

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