Evaluation Of Land Damage Status For Biomassa Production In Loakulu Subdistrict Kutaikartanegara Regency Of East Kalimantan Province Indonesia

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Abstrack: The objective of the study was to identify the parameters of soil damage, so that the level of damage that occurs was known, as a decision-making material with an appropriate approach to the problem, so that the productivity of the land does not decrease, even increased as a cultivation area that has a function for biomass production. The first step is to determine the potential for indicative soil damage by overlaying with the GIS-based digital map, i.e. soil type map, slope, rainfall, land cover, then with the spatial and regional plan map. The results obtained 4 classes of potential indicative soil damage, namely low (1), medium (2), high (3) and very high (4). Observations were made at (3) and (4). Number of field observation points and soil samples respectively 4 and 2. Field verification found that an effective soil depth (solum thickness) at (3) was ≥90 cm, 25-40% slopes were used for agriculture, whereas (4) was <20 cm and ≥60% only secondary forest. The results of the evaluation found that 5 parameters exceeding the threshold, namely solum thickness (s), surface of rocks (b), permeability (p), soil acidity (a) and electrical conductivity (e). Based on the relative frequency score, the soil damage status is slightly damaged at (3) by limiting factor (a) or D.I-a, while at (4) moderately damaged by limiting factor (s), (b), (p) and (e) or D.II-s, b, p, e. Improvement actions in D.I-a are soil treatment, organic fertilizing (compost) and liming, whereas in D.II-s, b, p, e is difficult to repair due to natural factors.

Keywords: Parameter of Soil Damage, GIS, Biomass Production

1 INTRODUCTION

Soil, as one of natural resources, is one of the most important factors to be the media for biomass production and environment. As the media of biomass production, the uses of soil have to be regulated, kept, and maintained, otherwise the function of biomass production could be disturbed or damaged. Soil is very crucial for lives that make it as an object of sustainable development for better living [1]. The utilization of soil, especially in the forest area or the area where many kinds of plants grow in Loakulu subdistrict, Kutaikartanegara regency, East Kalimantan Provinsi, had begun since the beginning of 1970's when the government granted forest concession rights to take timber. Utilizing the forest was very wide and quick since some time later it was used for coal mining and oil palm plantations. Forest is the main protection for soil layers which function as the media for the plants that grow in the area. If the trees were cut down, the soil would be open and damaged the soil and the environment such as turbidity and sedimentation caused by erosion. The acceleration of soil erosion, which is caused by anthropogenic activities like converting natural ecosystem into agro ecosystem and mechanical processing, can trigger many bad impacts to the ecosystem [2]. Utilizing the soil for mining activities and plantations needs to be well conducted by knowing the location and identifying the soil characteristics to anticipate worse damages.

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The objective of this study was to identify the parameters of soil damage, so that the level of the occurred damage could be known. This can be one of the considerations for the approach of decision making that suits the problem, so that the soil productivity would not decline but increase to be the area of cultivation that has the function of biomass production.

2 RESEARCH METHODS

The research materials are soil samples and maps, i.e. administrative map, soil type map, slope map, rainfall map, land cover map and spatial and regional spatial planning map. Digital-based maps are used to facilitate overlapping operations. Soil samples were taken at sites with high indicative soil damage potential based on the result of overlapping thematic maps.

2.1 Indicative Soil Damage Parameter

Indicative degradation parameters are soil type, slope, rainfall, and land cover measured weight based on their effect on soil damage. The parameter weights written in the sign () are: soil type (2), slope (3), rainfall (3), and land cover (2). The total number of weights is 10. The value of sub parameter () is in accordance with its potential damage. Soil type Vertisols aquik moisture regime (1), Oxisols (2), Mollisosl and Ultisols (3), Inceptisols, Entisols and Histosols (4), Andisols and Spodosol (5). The weight of the slope is measured in percent (%) groups, namely: 1-8 (1), 9-15 (2), 16-25 (3), 26-40 (4) and> 40 (5). Rainfall is grouped by volume in millimeters per year ($mm.th^{-1}$), i.e.:> 4000 (5), 3000-4000 (4), 2000-3000 (3), 1000-2000 (2) and <1000 (1). Land cover is divided into 4 groups: swamps, dryland forests, primary mangrove forests, secondary mangrove forests, secondary swamp forests, swamps and ponds (1); Mixed gardens, scrub, grass (2); Production forest, plantation forest, dryland farming, cultivation (3); Seasonal crop (4); Mining and open land (5). Each weight is multiplied by the parameter value to generate the score. The next stage is to perform overlapping operations using ArcGis

10.2. As for the result, the total score is a minimum of 10 and a maximum of 50. Based on the total score, the classification of indicative soil damage is divided into five classes. Map of potential indicative soil damage is piled up with map of spatial and area plan to take effective area i.e. cultivation area especially agriculture area, plantation and forest plantation.

Table 1. *Potential of indicative soil damage based on scores [3]*

Potential Damage	Total Score
Very Low	<15
Low	≤ 15-24
Medium	≤25-34
High	≤35-44
Very High	≤45-50

2.2 Field Verification
Field verification is done at very high-level indicative soil damage sites that are easy to reach to prove the truth of potential damage. Environmental observations include depth of soil, rocks or gravel, permeability measurements and removal of six soil samples at a depth of 0-20 cm. Soil samples were analyzed in the laboratory by covering physical properties (texture, fraction composition, bulk density, total pore), chemical properties (pH, EC and redox), and soil biology (bacteria and fungi).

2.3 Preparation of Land Damage Status
The soil damage status is determined by the relative frequency scoring method (RFS), i.e. the ratio of the number of soil samples classified as damaged from parameters (physics, chemistry, biology, depth, rocks and permeability) to all field samples, as presented in the Table 2 and Table 3

Table 2. *Score of soil damage based on relative frequency [3]*

Relative Frequency of Damaged Land (%)	Score	Damage Status
0-10	0	Not damaged
11-25	1	Light damage
26-50	2	Medium damage
51-75	3	Heavily damaged
76-100	4	Extremely heavy damage

Each parameter is scored and summed, then categorized its soil damage status.

Table 3. *Relation score against soil damage [3]*

Symbol	Score	Damage Status
N	0	Not damaged
D.I	1-14	Light damage
D.II	15-24	Medium damage
D.III	25-34	Heavily damaged
D.IV	35-40	Extremely heavy damage

The dry land soil criteria consist of 10 parameters with each critical threshold [4]. Parameters of soil thickness, surface rock and permeability were determined during field verification, while other parameters of the soil sample were analyzed in the laboratory.

Table 4. *Criteria of soil damage [4]*

Parameters	Symbol	Critical Threshold
Solum thickness	s	< 20 cm
Rock of surface	b	< 40%
Sand fraction composition	f	< 18% colloid; >80% quarcatic sand
Bulk density	d	> 1.4 $g.^{-1}cm^{3}$
Total porosity	v	<30% ; >70%
Permeability	p	<0.7 $cm.hour^{-1}$; >8 $cm.hour^{-1}$
pH (H_2O) 1 : 2.5	a	<4.5 ; >8.5
Electrical conductivity (EC)	e	>4.0 $mS.cm^{-1}$
Redox	r	<200 mV
Number of microbes	m	<10^{2} $cfu.g^{-1}soil$

3 RESULTS AND DISCUSSIONS

3.1 Score For Every Parameter
Based on the soil map [5] in the observations area were types of Inceptisols soil and Ultisols soil. The level of the slope was very steep (0->40%) with flat landform, rolling to hillocky. The distribution of the rainfall was between 1000-3000 $mm.annum^{-1}$. The scores for each parameter to decide indicative class of soil damage [3] are: Ultisols (6), Inceptisols (8). The score for the slope was 1-8%(3), 9-15%(6), 16-25%(9), 26-40% (12), and >40%(15). The score of the rainfall was 1000-2000 (6) and 2000-3000(9). There were 8 classes of the land covers [6] which were divided into four groups with the scores [3]: swamp, dry land forest, secondary swamp forest (2); bushes (4); forest plantations, dry land plantations (6); mining, open land (10).

3.2 Overlaying Map
From the result of overlaying the map for all parameters, the score was gained between 17-48 which means the indications of potential damages vary from low to high. Polygon was chosen as field verification for high and very high indicative class of soil damage with the consideration of accessibility.

3.3 Field Verification
After field verification was conducted, the parameters of solum thickness damage (s), rocks surface (b) and the permeability (p) vary. The parameter of high indicative class was solum thickness (s) ≥90cm, rock of surface (b) 0-2% and permeability (p) 1,43-4.64 $cm.hour^{-1}$, slope 25-40%. There were plantations such as palm trees, rubber trees, mixed plantations and horticulture. The parameter of very high indicative class was solum thickness (s) <20cm, and rock of surface (b) ≥50% in the form of loose rocks and open rocks and permeability (p) 8,15-9,16 $cm.hour^{-1}$, slope ≥60%, secondary forests. In every observation, some soil was taken to be the sample, the procedures were in accordance with [7],[8]. The samples number 1-4 were classified as high indicative class and 5-6 were very high indicative class.The type of the soil found was Ultisols considering [9].

3.4 The Evaluation of Soil Damage Status
Based on the results of field verification and soil analysis in the lab, the evaluation was conducted only to the parameters beyond the critical threshold by comparing the criteria of soil damage to decide the relative frequency (RF), the score of relative frequency (RFS) and the status of soil damage (SDS). All parameters of soil damage are reported on Table 5.

Table 5. *Parameter Status Evaluation of Solum Thickness, Rock of Surface, Permeability, pH and Electrical Coductivity*

Soil Sample	solum thickness (cm	Status		Rock of Surface (%)	Status		Permeability (cm.jam^{-1})	Status	
		Damage	Good		Demage	Good		Demage	Good
1	≥90	-	✓	0	-	✓	3.16	-	✓
2	≥90	-	✓	2	-	✓	3.57	-	✓
3	≥90	-	✓	0	-	✓	1.63	-	✓
4	≥90	-	✓	0	-	✓	4.64	-	✓
Amoun	-	0	4	-	0	4	-	0	4
Threshold	<20			<40			<0.7; >8		
RF (%)	0/4 x 100% = 0.00			0/4 x 100% = 0.00			0/4 x 100% = 0.00		
RFS	0			0			0		
SDS	Not Demage			Not Demage			Not Demage		
5	18	✓	-	50	✓	-	9.16	✓	-
6	15	✓	-	50	✓	-	8.15	✓	-
Amoun	-	2	0	-	2	0		2	0
RF (%)	2/2 x 100% = 100.00			2/2 x 100% = 100.00			2/2 x 100% = 100.00		
RFS	4			4			4		
SDS	Extremely heavy damage			Extremely heavy damage			Extremely heavy damage		

Advanced Table 5

Soil Sample	pH (H_2O)	Status		EC (mS.m^{-1})	Status	
		Damage	Good		Damage	Good
1	3.85	✓	-	3.36	-	✓
2	3.71	✓	-	3.30	-	✓
3	4.10	✓	-	199	-	✓
4	5.02	-	✓	2.71	-	✓
Amoun	-	3	1	-	0	4
Threshold	<4.5 ; >8.5			>4.0		
RF (%)	3/4 x 100% = 75.00%			0/4 x 100% = 0.00%		
RFS	3			0		
SDS	Heavily damaged			Not damaged		
5	6.43	-	✓	9.35	✓	-
6	6.03	-	✓	7.05	✓	-
Amoun	-	0	2	-	2	0
RF (%)	0/2 x 100% = 0.00%			2/2 x 100% = 100.00%		
RFS	0			4		
SDS	Not damaged			Extremely heavy damage		

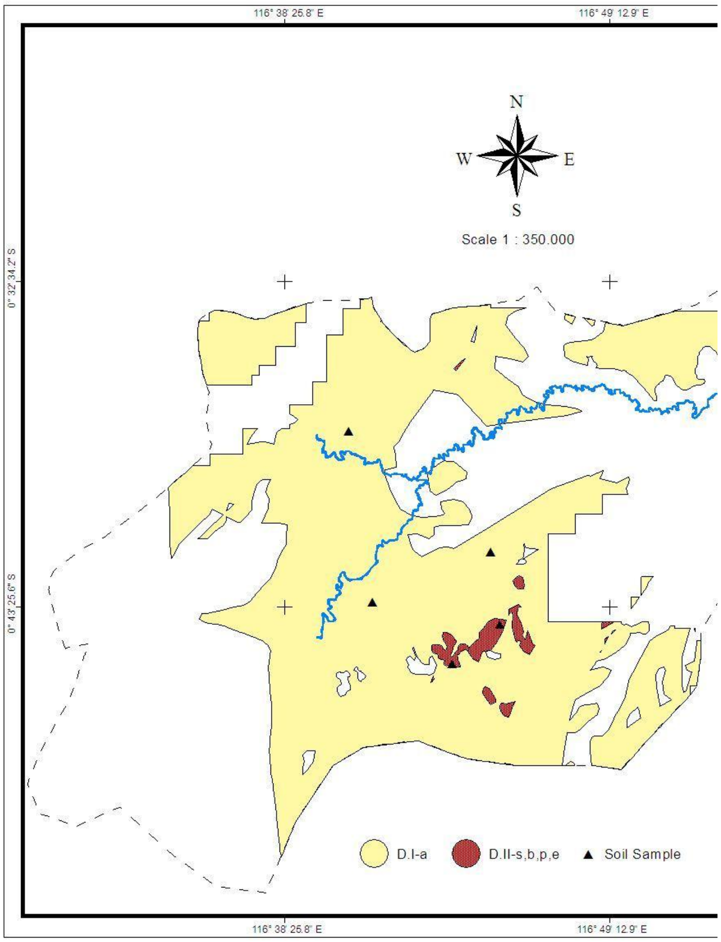
3.5 Soil Damage Status

To get the status of soil damage, the RFS was summed based on the evaluation of every parameter. There were 5 parameters that the RFS scored ≥0 which means did not affect anything (was not damaged) and influenced to the increase of soil damage status with maximal value 4 (heavily damaged) i.e. solum thickness (s), rock of surface (b), permeability (p), the acidity level (a) and electric conductivity (e), meanwhile other parameters scored 0 (zero) which means it was not affected. On high indicative class of soil damage, it was only parameter (a) that gave influence with the score 3. On very high indicative class of soil damage, there were four parameters that were influencing with maximum score 4; they are (s), (b), (p) and (e). The sum of RFS determined the class of soil damage status, as presented in the Table 6.

Table 6. *Parameters of damage and relative frequency score*

Parameter	Symbol	RFS	
		High indicative soil damage	Very High indicative soil damage
Solum thickness	s	0	4
Rock of surface	b	0	4
Composition of sand fraction	f	0	0
Bulk density	d	0	0
Total porosity	v	0	0
Permeability	p	0	4
pH (H_2O) 1 : 2.5	a	3	0
Electrical conductivity	e	0	4
Redox	r	0	0
Number of soil microbes	m	0	0
Number		3	16
Soil Damage Status		Light Damage	Medium Damage
Symbol		D.I-a	D.II-s,b,p,e

Based on the calculation of RFS for high indicative class of soil damage, score 3 was gained. This means the status of soil damage was lightly damaged (D.I) with limitation factor (a). Meanwhile for very high indicative class of soil damage the sum of the scores was 16 which means it was moderately damaged (D.II) with limitation factor (s), (b), (p) dan (e). Limitation factor (a) could be repaired, whereas limitation factors (s), (b), (p) dan (e) were difficult to repair because their characteristics that were permanent and needed much feedback [10]. According to the parameter of soil acidity (pH), there were three soil samples that their acidity levels were below the threshold (<4.5) which means it had high acid [11]. Ultisols soil in Loa Kulu subdistrict and East Kalimantan in general was formed from main sediment rocky sand materials and clay rocks [12], pH 5.0-3.1 (moderate acidity-high acidity), low Cation Exchange Capacity (CEC) and saturated Al between 33-95% [13]. Solution of Al which was high on Ultisols soil could bind P so that the availability was declined although it contained high P, besides it was lack of P because P contained in the main material was low [14]. When field verification was conducted, the color of soil section was brownish and reddish, except on horizon A, it was a bit blackish which means there was organic matter, the soil depth (≥90 cm). The brownish and reddish colors were formed because of Fe-oxides such as goethite and hematite [15]. Although it was natural, the acidity factor characteristic can be repaired. The pH level could be increased to >4,5 or could be decreased to 4.5-5.5 (acid) and pH 5.6-6.5 (rather acid) [10]. The repair could be done by hoeing or plowing followed by giving lime 2-4 ton.ha^{-1}. This can be done as a conventional technology in repairing soil acidity so that the Al solution could be decreased [16],[17]. Another way can be taken such as by fertilizing the soil with organic materials like compost [18]. Organic materials can maintain soil acidity in order to keep the acidity level steady because they have buffering effect that can keep the soil acidity [19]. Based on the field verification, the observed plants especially oil palm, banana trees, and corn which were located in different soil samples 1-4 had been seen well grown. It was because they were planted on the soil that was not used for some time in which it was observed by the cut-trees which had 20-40 cm diameter. The appearance indicated that the soil nutrient was still enough for plants needs. However, if the soil was expected to be able to be used for longer and more sustainable purposes, it would need fertilizer. From the observation results, the reserve of soil nutrient was enough, especially on the superficial soil (0-15 cm) for 2-3 times crop rotation, after which productivity will decrease significantly. The types of local plants in general, especially the annual crops such as Durio zibethinus, Durio kutejensis, Lansium domesticum, Arthocarpus integer and Nephellium lappacium that could grow and produce well. It was suspected to happen because these plants were able to adapt the environment which was not very fertile and indicated to have high acidity level. It could be proven by the existence of some old plants in the area that aged for hundreds of years are still in production indicating adaptation with the environment goes well.



Picture 1: *Map of soil Damage Status to Biomass Production at study site*

4 CONCLUSION

Based on the results and analysis it can be concluded that the indicative class of high soil damage, the damage status is lightly damaged by limitation factor of high acidity of soil (pH 3.85 - 4.10) this cover an area of 51,632.16 ha. The acidity factor can be improved by liming, composting and soil treatment or cultivation, so that the damage status becomes undamaged. The indicative class of very high soil damage, the damage status is moderately damaged by unrepaired limiting factors, such as solum depth, surface rocks, soil permeability and electric conductivity, this covers 851.78 ha.

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