

Detection of Land Damage for Biomass Production with Thematic Overlays based Geographic Information Systems

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Date Received: 18th December 2019 / Date Accepted: 30th January 2020

ABSTRACT

Purpose : Nationally, not all regions in Indonesia have detected land damage for biomass production. Whereas the determination of land damage needs to be done as an effort of its control. The aim of this study is to compile a map of the status of soil and land damage for Biomass production.

Research Method : This research was conducted with a scoring calculation method with a thematic map overlay using a Geographic Information System.

Findings : The results showed in 12 study areas, where they had an area of 58.509,31 ha of Effective Work Area, with three categories of potential land damage, namely 56.96% moderate damage, 43% minor damage, and 0.004% very mild damage.

Limitations : It would be better taking a sampling point even if the soil type is the same.

Value : As a form of the Minimum Service Standards for the Environment Sector, which is status information service based on the standard criteria for national land damage.

Keywords: land damage, biomass production, map overlay

INTRODUCTION

The land has a function as a matrix where the roots of anchor plants and water are stored. Therefore, the process of restoration of soil ecological functions becomes important especially in increasing the production of biomass which is very important for human welfare. In Ghana, mapping information on land damage for biomass production has been applied and is consistent in developing environmentally friendly agriculture in each district. One of the biggest challenges is reversing land management properly and unsustainable degradation. Technology and innovative principles must be applied to characterize land.

Determination of land damage status for biomass production needs to be done as an effort to control land damage. Land damage for biomass production can be caused by its natural nature, it can also be caused by human activities that cause the land to be disturbed / damaged

until it is no longer able to function as a medium for normal biomass production. According to Mohamed and Abdel Rahman strengthened by opinions of Kjeld Rasmussen, Cheikh Mbow, Yunjia Wang, and Rasmus Fensholt the incorporation of soil survey information can be integrated in a geographic information system (GIS) to assess the suitability of plants for various soil and biophysical conditions. This study was carried out in effective work areas, namely, agriculture, plantation, and plantation areas whereas other areas (protected areas, other cultivation areas such as fishing ponds, settlements) are not included as effective work areas.

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Subang Regency with a total area of 205.176,95 hectares or around 6.34% of the area of West Java Province is faced with the problem of potential damage to land resources. The encroachment of protected forest areas and land uses that are not suitable for their allotment and carrying capacity are actions that may be taken by the community due to increased population growth accompanied by an increase in their living needs including food, clothing, and housing. The location has been chosen for review and then the condition of the land damage status is determined based on the measurement results (the standard criteria for soil damage for biomass production in 2018). The activity of compiling Information and Monitoring the Status of Damage to Biomass Production Land in Subang Regency 2018 is in the form of documents resulting from monitoring and inventory of potential damage to biomass production land. According to Gibbs and Salmon (2018) land degradation is often suggested as a solution to the problem of land scarcity and as an ideal way to do it in meeting the increasing global demand for agricultural products.

MATERIAL AND METHOD

The study area is part of the Central and Southern Subang District covering twelve districts: Ciater District (6.572,18 ha), Cikaum District (7.545,44 ha), Cisalak District (9.922,46 ha), Dawuan District (9.335,03 ha), Jalancagak District (5,323.54 ha), Kasomalang District (5.029,10 ha), Pabuaran District (7.408,41 ha), Pagaden District (4.890,30 ha), West Pagaden District (5,064.82 ha), Purwadadi District (7.585,83 ha), Sagalaherang District (5.159,37 ha), and Serangpanjang District (7.202,68 ha).

The equipment used in this study includes field and laboratory equipments; steel ring sampler for intact land sampling, physical soil characteristics, composite soil sampling disturbed by drill and hoe, for analysis of soil chemical and biological properties. Garmin 62S handheld GPS, measuring instruments, documentation, abney level, stationery, striker

labels, and plastic bags and ArcGIS 10.6 for making work maps and results maps.

Laboratory equipment is used to measure and establish land characteristics after field ground check. Some maps: land use maps, land maps, slope maps, (Fine Earth Map, Bakosurtanal / BIG). The term topographical features can also be found in Presidential Regulation (Perpres) Number 112 of 2006 concerning Standardization of Topographical Names. Term the second for topographic names is geographical names. This name still remains used by some people, including academics. The third term for name topographical is a toponym. This word comes from the Greek, meaning topos place and onyma meaning names (Rais, *et al.*, 2008) then overlaid and scored to produce a map of potential land damage. The initial stage of preparing the initial Condition Map is to capture the effective work area through overlays with the Regional Spatial Planning Map. The weighting score for potential land damage is obtained by multiplying the rating value, namely, the potential value of each element of the thematic map to the occurrence of the land damage with the weight value of each thematic map (Technical Guidelines of the Ministry of Environment, 2009). The rating value is set to the range from 1-5. Land cover maps and land maps are given a weight value of 2 (two), slope and rainfall maps are given a weight of 3 (three). The higher the weighting scoring value, the higher the potential for the area to be experienced land damage. Scoring potential for land damage can be seen in Table 01.

Spatial analysis is done by overlaying some of the spatial data parameters determining land damage. Preliminary Condition Map in principle presents information on the alleged potential damage to the land in Figure 01.

This map will be used as a work map and aims to facilitate and direct verification in the field, especially in determining the priority of locations to be surveyed for measurements to be processed. For this purpose, it is necessary to know land damage, namely, land type, slope, annual rainfall and land use.

Table 01: Scoring Potential Damage based on Thematic Map

Soil	Potential Land Damage	Symbol	Rating	weighting score (rating x weight)
Vertisol. soil with an aquatic moisture regime	Very lightly	T1	1	2
Vertisol. soil with an aquatic moisture regime				
Oxisol	Lightly	T2	2	4
Alfisol. Mollisol. Ultisol	Moderate	T3	3	6
Inceptisols. Entisol. Histosols	High	T4	4	8
Spodosol. Andisol	Very High	T5	5	10
Slope (%)				
1 – 8	Very lightly	1.1	1	3
9 – 15	Lightly	1.2	2	6
16 – 25	Moderate	1.3	3	9
26 – 40	High	1.4	4	12
>40	Very High	1.5	5	15
Rain Fall (mm/th)				
< 1000	Very lihgtly	H1	1	3
1000 – 2000	Lightly	H2	2	6
2000 – 3000	Moderate	H3	3	9
3000 – 4000	High	H4	4	12
>4000	Very High	H5	5	15
Land Use				
Nature forest; Rice field Pure Imperata Reeds	Very lightly	T1	1	2
Plantation Shurbs	Lightly	T2	2	4
Production Forest	Moderate	T3	3	6
Annual Plant	High	T4	4	8
Deforestation	Very High	T5	5	10

Tabel 02: Criteria for classifying potential soil damage based on scores

Potential soil damage	Weighting score
Very mild	< 15
Minor	15 – 24
Moderate	25 – 34
High	35 – 44
Very high	45- 50

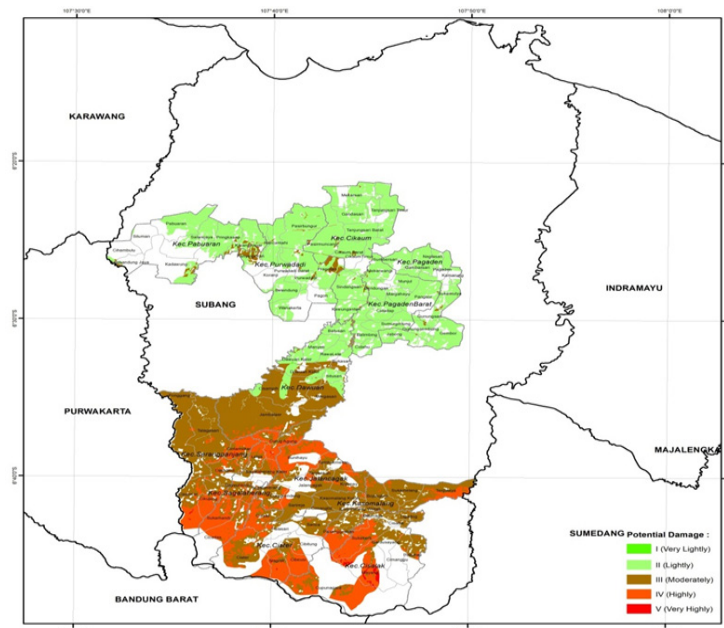


Figure 01: Potential land damage map

Potential land damage is estimated by grouping the weighting score accumulation, which is the product of the score with the weight of each thematic map. This potential assessment is carried out on polygons generated through the overlay process. The value of the accumulated score ranges from 10 - 50. The maximum value occurs if all the attribute values from each used thematic map have a very high potential for soil damage and are listed in Table 02.

The field survey aims to improve the map of the results of the preparation of potential land damage by taking a coordinate sample (Table.03) with a sampling intensity of 2.5% of

the priority area. Then the input map is reviewed and overlaid again.

Laboratory Analysis

Soil parameters for dry land as regulated in Minister of Environment Regulation No. 7 of 2006 concerning Procedures for measuring the criteria of Damage to Land for Biomass Production include: Solum Thickness, Surface Unity, Fraction Composition, Bulk Density, Total Porosity, Water Graduation Degree, pH, Electrical Conductivity, Redox Value, Amount of Soil Microbes. All parameters mentioned are shown in Figure 02.

Table 03: Coordinates of Sample Points in the Study Area

Land used	X	Y
Plantation	792685.939	9253309.122
Dry land	804401.515	9255758.753
Plantation	803431.873	9257921.448
Rain-Field Rice	792023.918	9260122.121
plantation	788107.036	9260476.475
Irrigated Field Rice	799996.545	9263130.205
Rain-Field Rice	797454.856	9273555.976
Plantation	802668.997	9278605.280
Irrigated Field Rice	810779.474	9282201.524
Dry land	797166.676	9288649.672
Dry land	792302.548	9289856.040
Irrigated Field Rice	806173.080	9291882.811

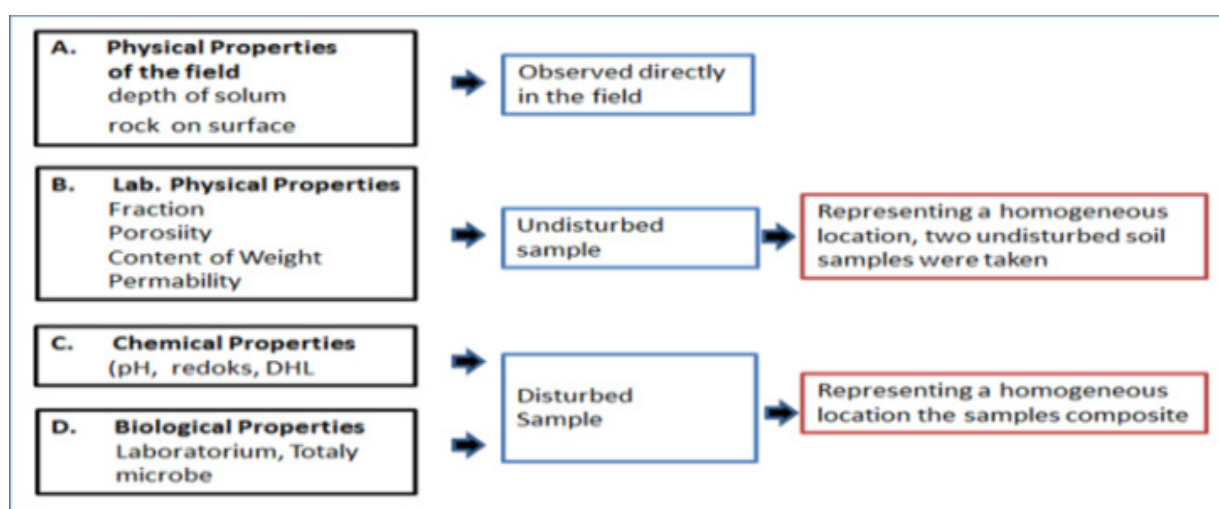


Figure 02: Scheme of Analysis of Dry Soil Quality Samples

Table 04: Standard Criteria for Soil Damage

No	Parameter	Critical threshold	Measurment Metode	Tools/Equipment
1	Solum Thicknes	<20 cm	Direct measurment	Tape measure
2	Surface rocks	>40 %	Direct measurement of stone and soil balance in a unit area	Tape measure: Counter (line orto-tal)
3	Fraction composition	<18% claycoloid >80 Quartz sand Coarse sand	Color of sand. Gravimetric	Graduated cylinder/beaker glass/Weigher/steel yard
4	Bulk Density	>1.4 g/cm ³	Gravimetry In units of volume	Candles. measuring tubes; ring sampler. analytical balance
5	Totally porosity	<30 % ; >70 %	Calculation of content weight (BI) and specific gravity (BJ)	Picnometer; double ring permeameter
6	Permeability	<0.7 cm/jam > 8cm/jam	Permeability	Ring sampler; dou-ble ring Permeameter
7	pH (H ₂ O) 1 : 2.5	<4.5 : >8.5	Potentiometrics	pH meter; pH stick 0.5 scale unit
8	Electrical conductivity	>4.0 ms/cm	Electric resist	EC Meter
9	Redoks	< 200 mV	Electrical voltage	pH meter: platinun electrode
10	Total of microbe	<102 cfu/g tanah	Plating technique	Petri dish: Colony Counter

Steps to determine the level of land and land damage:

1. Calculate the relative frequency (%) of each land damage parameter.
2. Rating for each parameter based on relative frequency with a range value of 0 - 4;
3. Add up the scores for each damage parameter of the soil.
4. Status of land damage is determined by the number of scores in point 3.

RESULT AND DISCUSSION

Field verification is an activity to prove the indication of land damage that has been compiled from the results of field observations. Verification is carried out at the point of sampling and laboratory testing entered into the database from the total score given by categorizing the level of land damage listed

in Table 05. The next step is to prepare a map of land damage obtained from a combination of potential damage maps and results of soil analysis in the laboratory. Based on the status of the damage this is divided into five categories namely, undamaged (N), lightly damaged (RI), moderately damaged (R.II), heavily damaged (R.III) and very heavily damaged (R.IV). (1) Ciater. (2) Cikaum (3) Cislak (4) Dawuan (5) Jalancagak (6) Kasomalang (7) Pabuaran (8) Pagaden (9) Pagaden Barat. (10) Purwadadi (11) Sagalaherang (12) Serangpanjang.

The database can be displayed in Table 05 and matched with the standard criteria for soil or land damage. The results of determining the damage status of the land are used to revise the map of potential land damage resulting from an overlay of spatial parameters (slope maps. rainfall maps. land cover maps. and maps of the distribution of soil types). In Figure 03 of the land damage status map very lightly marked in green is not visible.

Table 05: Analysis of land damage database in the study area

Parameter analysis	I	II	III	IV	V	VI	VII	VIII	IX	X	XI	XII
District	1	2	3	4	5	6	7	8	9	10	11	12
Potential Damage	H	H	H	H	H	H	M	M	M	M	M	M
Symbol	PR-IV	PR-IV	PR-IV	PR-IV	PR-IV	PR-III	PR-III	PR-III	PR-III	PR-III	PR-III	PR-II
Solum Thickness	N	N	N	N	N	N	N	N	N	N	N	N
Specific Gravity g/cm ³	N	N	N	N	N	N	N	N	N	N	N	R-II
Total Porosity (%)	R-II	N	N	N	N	N	N	N	N	N	N	R-III
Permeability (cm/hour)	R-III	N	N	N	N	R-III	R-III	N	N	R-II	R-III	R-III
Surface rock	N	N	N	N	N	N	N	N	N	N	N	N
Fraction	N	N	N	N	R-II	N	N	R-II	R-II	N	R-III	R-III
pH H ₂ O	N	R-III	R-II	R-II	R-III	R-III	R-III	R-II	R-III	N	R-II	R-III
Electrical conductivity	N	N	N	N	N	N	N	N	N	N	R-I	R-II
Redoks (mV)	N		N	N	N	R-III	N	N	R-III	N	N	R-III
Amount of Microbes (cfu/g soils)	N	N	N	N	N	N	N	N	N	N	R-II	R-III
Pyrit/FeS ₂	N	N	N	N	N	N	N	N	R-II	N	N	R-III
Land Damage Status	R-III	R-III	R-II	R-II	R-III	R-III	R-II	R-II	R-III	R-II	R-III	R-III

H: High ; M: Moderate

Sources : Data is processed based on the results of laboratory soil research centers. 2018

Some areas that were initially, potentially of high damage experienced a decrease in damage status to moderate and mildly damaged after soil analysis in the laboratory. Based on Table 05 below from an effective working area of 58.509,31 ha. soil / land damage at a moderate level reached 33.328,16 ha. dominated by Serangpanjang District reaching an area of

6.412,40 ha. which is a mixed dryland garden united with melastoma bush (*Melastoma malabatricum*), Andisol soil type and the land has not been utilized optimally. The slope is of 16% -25%. So, it is necessary to make a mixed garden design based on vegetative conservation methods.

Table 06: Status of Soil Damage

No	District	Level of Soil damaged			Area (ha)
		I (Very mild)	II (minor/lightly)	III (Moderately)	
1	Ciater			4.310,68	4.310,68
2	Cikaum		6.128,37	139.74	6.268,10
3	Cisalak			4.695,02	4.695,02
4	Dawuan	4.59	3.321,94	5.056,14	8.382,67
5	Jalancagak			3.932,47	3.932,47
6	Kasomalang		2.24	4.477,01	4.479,25
7	Pabuaran		3.263,58	138.06	3.401,63
8	Pagaden		3.504,86	100.21	3.605,06
9	PagadenBarat		3.889,89	20.61	3.910,50
10	Purwadadi		5.065,69	214.78	5.280,47
11	Sagalaherang			3.831,04	3.831,04
12	Serangpanjang			6.412,40	6.412,40
	Grand Total	4.59	25.176,56	33.328,16	58.509,31

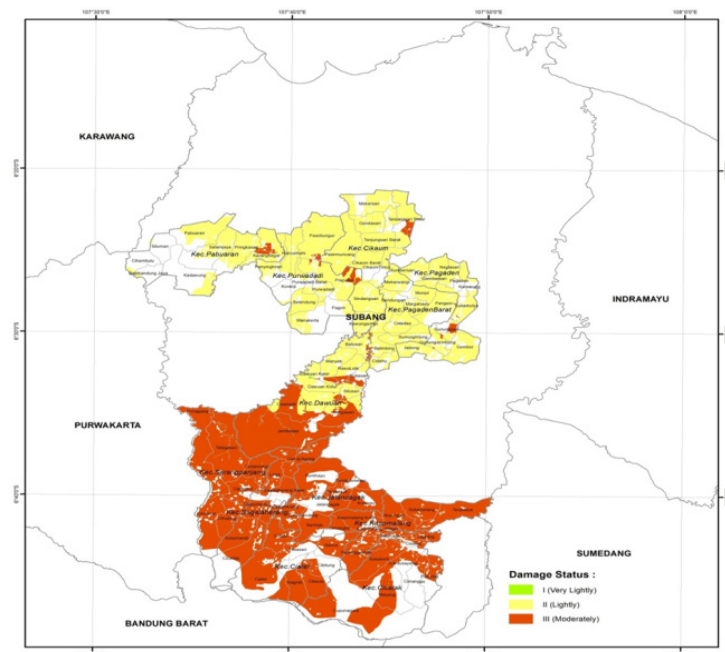


Figure 03: Land Damage Status Map

In Kasomalang District moderate damage was 4.695,02 ha. Land cover of mixed garden vegetation and soil / land damage can be seen from the degree of water release / permeability very quickly reaching 15.42 cm / hour.

Soil damage of pH 3.8 as a leachate category of a number of bases in the soil layer and support of slope between 16% -25% of Latosol soil types. If the land is to be used for better mixed garden design it should be adjusted to greening patterns utilizing agricultural lime and organic fertilizer (applying conservation with appropriate vegetative methods). Efforts to repair land damage can be done with conservation techniques both physically, chemically and biologically. Improvements can be done in several ways including the use of terraces on sloped lands, improved drainage on stagnant soils, lime application, ameliorant to improve soil pH and the provision of organic fertilizer to maintain soil conditions so as not to easily lose nutrients. According to Nunung Sondari (2017) one form of “safety net for leaching nutrients” is important. actions such as immersing forage materials are added to add organic material to the soil.

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CONCLUSIONS

The determination results for the status of soil/ land damage indicate that their status in the twelve Districts in the effective work area is 56.96% for the medium damage category, 43% for the mild damage category, and 0.004% for the very light category.

Data Availability Statement

All data generated or analysed during this study are included in this published article and are available with supplementary information files.

ACKNOWLEDGMENT

Authors would like to thank to Universitas Winaya Mukti for providing full support of research collaboration. Authors thank Subang Regency’s Office of the Environment for funding supports.

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