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SAINS TANAH – Journal of Soil Science and Agroclimatology, 15(1), 2018, 1-14
RESEARCH ARTICLE

STUDY OF SOIL DEGRADATION STATUS AT JATIPURNO DISTRICT, KEDUANG SUB-WATERSHED, WONOGIRI REGENCY, CENTRAL JAVA

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Submitted: 2017-08-02 Accepted: 2018-02-22

ABSTRACT

This study is aimed to evaluate soil degradation based on Standard Criteria of Soil Degradation for Biomass Production under Indonesian Government Regulation No. 150 in 2000. Conducted at Jatipurno District, Keduang Sub-Watershed, between October and December 2016, at seven selected land units, each land unit is represented by four sample points. The selection of sampling area is according to Stratified Purposive Sampling method. The evaluation of soil degradation is carried out by determining the threshold value and key factors of soil characteristics based on the Standard Criteria of Soil (matching process), which lead to degradation. The results showed that the entire soil at Jatipurno District is slightly degraded. The most extensive soil degradation 2,869.31 ha area (69.60%) is caused by a low colloid fraction, high bulk density, low total porosity, and low soil permeability. The soil degradation mostly caused by low soil permeability which the number is under critical threshold < 0.7 cm hour^{-1} in the entire land units. Implementing providing organic matter to the soil, planting variations of cover crops, on land plots (low, medium, high cover crops), land management by crop rotation and intercropping, minimum tillage in accordance with the rules of environmental conservation, can be done to minimize the soil degradation.

Keywords: environmental conservation, soil degradation, soil permeability

How to Cite: Widiatiningsih, A., Mujiyo, Suntoro (2018). Study of Soil Degradation Status at Jatipurno District, Keduang Sub-Watershed, Wonogiri Regency, Central Java. Sains Tanah Journal of Soil Science and Agroclimatology, 15(1): 1-14 (doi: 10.15608/stjssa.v15i1.862)

Permalink/DOI: http://dx.doi.org/10.15608/stjssa.v15i1.862

INTRODUCTION

The land is one of the element or component with soil inside, where it has many functions in life (Gibbs & Salmon, 2015). The soil is where the biomass is produced, which supports human's life, has dynamic characteristic and play many key roles in the land ecosystem. The soil is the mixture of the mineral particle, organic material, gas, and rich in nutrition and also a home for billions of macro and micro-organisms (Liu et al., 2010).Soil degradation is believed as one of the main cause of the stagnant growth of food productivity. It refers to the process, mainly caused by human error, where the degradation of land quality is caused by land misuse, for example in food productivity (Bindraban et al., 2012). The ineffective land use of agricultural land and the miss-use of the land ability will cause physical, chemical and biological degradation to the soil or it also called with degraded land (Rahman, Harisuseno, & Sisinggih, 2012). The management of natural resources, mainly land

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resources, has a more significant role specifically in the effort of sustainable land use. The natural resources are prone to degradation or quality decrease (Suyana, Sinukaban, Sanim, & Purwanto, 2009). Degraded lands are the center of much attention as global demands for food, feed and fuel continue to increase at unprecedented rates, while the agricultural land base needed for production is shrinking in many parts of the world (Gibbs & Salmon, 2015).

Potential lands for agricultural use, are recently converted to non-agricultural land, so thus agriculture activities are transferred to the degraded land, which needs higher and more expensive inputs in the management, to reach out qualified output (Wuryanta & Susanti, 2015). The over-use of chemical materials in order to increase land productivity may lead to the soil degradation. Soil degradation is the loss or decrease of land function, not only a source of nutrients for plants but also as the matrix of a place for roots grow and water save (Sitanala, 2010). According to the Law Number 32 in 2009, the degradation of the living environment has threatened the survival of the human and another organism, thus it needs real and consistent management of living environment by all parties (the Republic of Indonesia, 2009). The degradation of land resources, particularly at the upstream of the watershed, will lead to decrease in land productivity, ecological function and hydrological function (Suyana et al., 2009). In this ecosystem, human activities cultivated natural resources such as lands, water, vegetation, and other biodiversity. In last decades, unwise usage of natural resources in watershed caused acceleration soil erosion hazard, degrading productivities on forest and agricultural land and sedimentation on the river, and lowland. Depletion of watershed productivities nowadays is mostly caused by mismanagement and poor coordination among stakeholders in controlling and managing natural and human resources within the watershed (Amri, Barchia, & Aprizal, 2017). The watershed area needs good management to be able to run diversification function of sustainable biomass production, giving advantages to social economy aspects, land-coverage environmental aspect, and water management regulator (Rahayu, 2017). The evaluation of land quality and monitoring are needed to gain recommendation in protecting production sustainability, mainly in agricultural field (Mujiyo, Rahayu, Ustiatik, & Anggrahini, 2016).

The observation of primer parameters of soil degradation criteria is conducted according to the ruled method in Government Regulation Number 150 in 2000 (Government of Indonesia, 2000). Technically, procedures of the parameters measured are explained in the Environment Ministry Regulation Number 7 in 2006. Some parameters are directly measured and identified on the field, while some others are measured through laboratory analysis (Indonesia Natural Resources Ministry, 2006). Soil degradation is often occurred by human-activity causes which managing and utilizing land without considering land capability and suitability.

Jatipurno District in Wonogiri regency is included in the area of Keduang watershed. The District has 5,545 ha of land, with 1,423.17 ha (25.66%) of the land are used for residential areas, 1,620.54 ha (29.23%) of the land are for dry land, 1,418.80 ha (25.59%) of the land is for rice fields, 739.18 ha (13.33%) are for farms, and 343.31 ha (6.19%) are for forests (The Central Statistical Agency of Wonogiri District, 2016). The usage of the land that involves humans will cause both positive and negative impacts on the environment, mainly for soil condition in Jatipurno District. In 2015, the area of degraded land in the upstream of Keduang watershed was 7,993 ha. It consists of

1,200 ha of not degraded land (15%), 2,546 ha of potentially degraded land (31.85%), 1,932 ha (24.71%) of slightly degraded land, and 2,315 ha (28.96%) of degraded land in the upstream area of Keduang watershed (Pratama, 2015).

Jatipurno District has not recorded any data related to the degraded-soil in this area. And thus this study is conducted to identify the soil degradation status in the District, which is based on land's actual data. This is important work by considering that land usage is becoming more intensive. The purpose of this study is to identify soil degradation status in the District.

MATERIALS AND METHODS

This study is conducted atJatipurno District, which is part of Keduang watershed, located on 7°47'56" S and 111°8'3" E. The soil chemical, physical and biological analyses were conducted at the laboratory of Agricultural Faculty, Sebelas Maret University. This study was carried out from October to December 2016.

This study is descriptive explorative research, conducted with survey method by observing and sampling to the field, supported by laboratory analysis. The land units are defined by overlaying the thematic maps, i.e.: 1) 1:25,000 thematic land use map (National Coordinating Agency for Surveys and Mapping, 2000); 2) 1:50,000 Rainfall map; and 4) soil type map (Semi Detail Land Map, Soil and Agro-climate Research Centre, first edition, 1994); and 5) slope map (National Coordinating Agency for Surveys and Mapping, 2000), with GIS ArcView 3.3 program.

The land use observed in this study is forest, rice fields, plantation fields, and dry land; the reason for selecting those land uses because they are effective for biomass production. Sampling points were determined after obtaining the measurement of a land unit. Each land unit is represented by four sample points and total 28 sample points. The sample points did not determine by land unit size. The requirement in taking the sample point that represents the administrative area in 11 villages/sub-districts, represents the type of land use available, represents the diversity of the slope, represents the diversity of rainfall, represents the land order, and represents the potential for soil damage in Jatipurno Sub-District.

The field tools and soil sampling equipment are sample ring, land drill, field knife, GPS, gauges, documents, Abney level, writing tools, label sticker, plastic bags and other laboratory tools used to measure and specify soil characteristics, also a unit of personnel was employed to specify the land units. The result of thematic map overlay, which is used for work map, shows that Jatipurno District has one type of soil namely Inceptisol. The land usage in the District for rice fields, dry land, farm, and forest. For the degree of slope in the District, is categorized into 0-8% (flat-wavy), 9-15% (wavy), 16-25% (hilly), 26-40% (hilly) and >40%. After obtaining land unit map and sampling point location, then verifying data of location and land unit measurement. The sampling point location and data of location coverage characteristic shown in Table 1.

The analysis of soil characteristics is taken from soil sample on the field, to identify the level of soil degradation, according to its main character stated on the Government Regulation Number 150 in 2000 which quality standard guidelines for soil degradation as seen in Table 2.

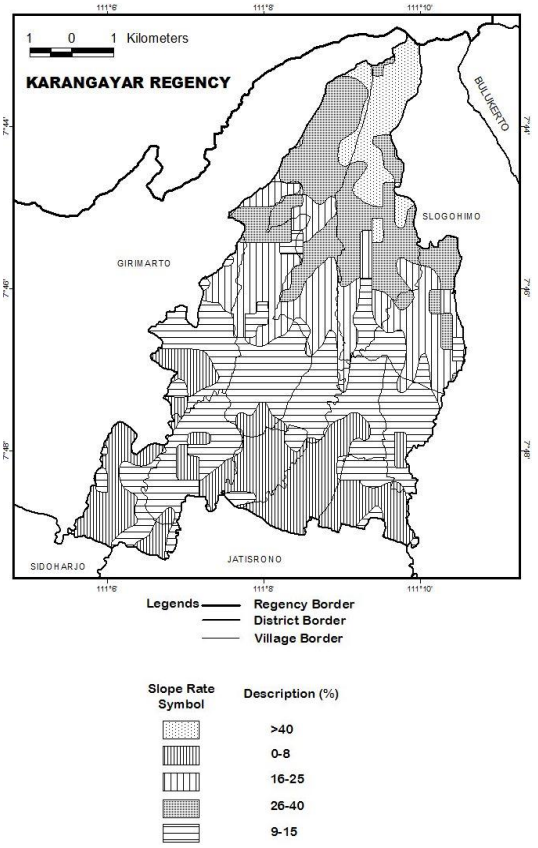


Figure 1. Map of Land Use

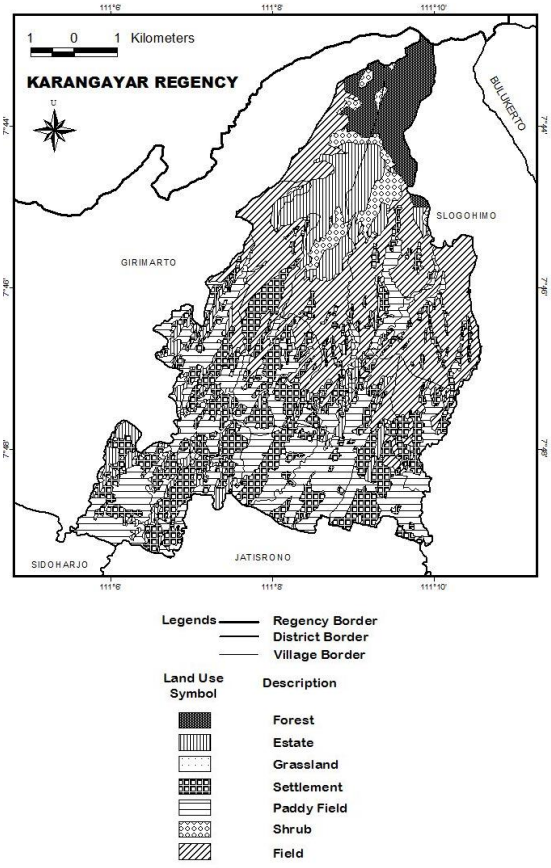


Figure 2. Map of Slope Rate

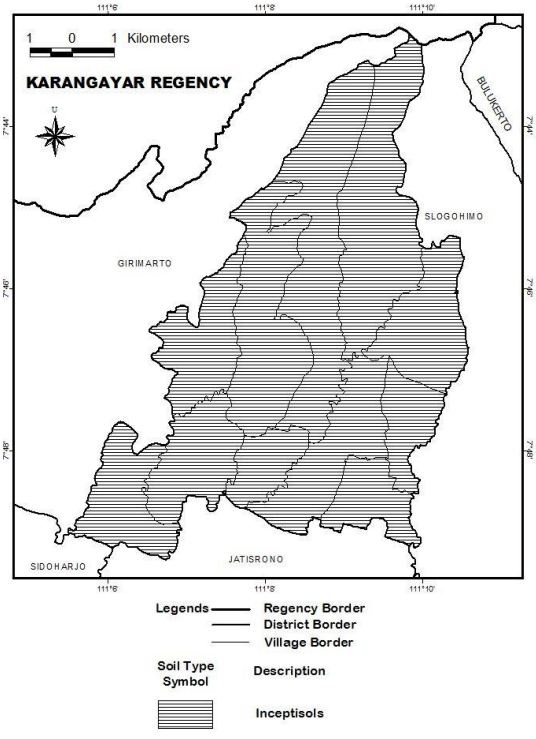


Figure 3. Map of Soil Type

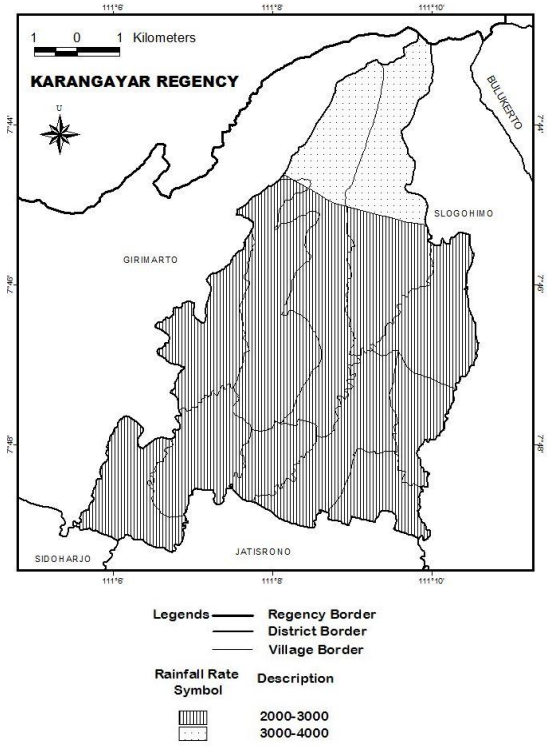


Figure 4. Map of Rainfall Rate

Table 1. Land Unit and Sampling Point Location in Jatipurno District

No.	Code	Soil Ordo	The degree of Slope (%)	Rainfall (mm year^{-1})	Land Use
1.	A	Inceptisols	0-8	2,000-3,000	Rice fields
5.	B	Inceptisols	16-25	2,000-3,000	Dry land
9.	C	Inceptisols	26-40	2,000-3,000	Dry land
13.	D	Inceptisols	26-40	3,000-4,000	Plantation Fields
17.	E	Inceptisols	9-15	2,000-3,000	Rice fields
21.	F	Inceptisols	9-15	2,000-3,000	Dry land
25.	G	Inceptisols	>40	3,000-4,000	Forest

Descriptions: Inceptisols is nearly similar with Regosol

The characteristics that observed in the laboratory are: *Soil texture* use the Gravimetric method, d*ensity* use Gravimetric on unit volume method (Rosyidah & Wirosoedarmo, 2013), t*otal porosity* use calculation of the unit weight of density and specific weight method. *Soil permeability* use *Falling Head Permeameter* method, *pH (H_20)* use the Potentiometric method, *Electrical conductivity* use electrical resistance method, *Redox* uses electrical voltage method *Number of microbes* use Standard Plate Count method (Hamada, Matar, & Bashir, 2015).

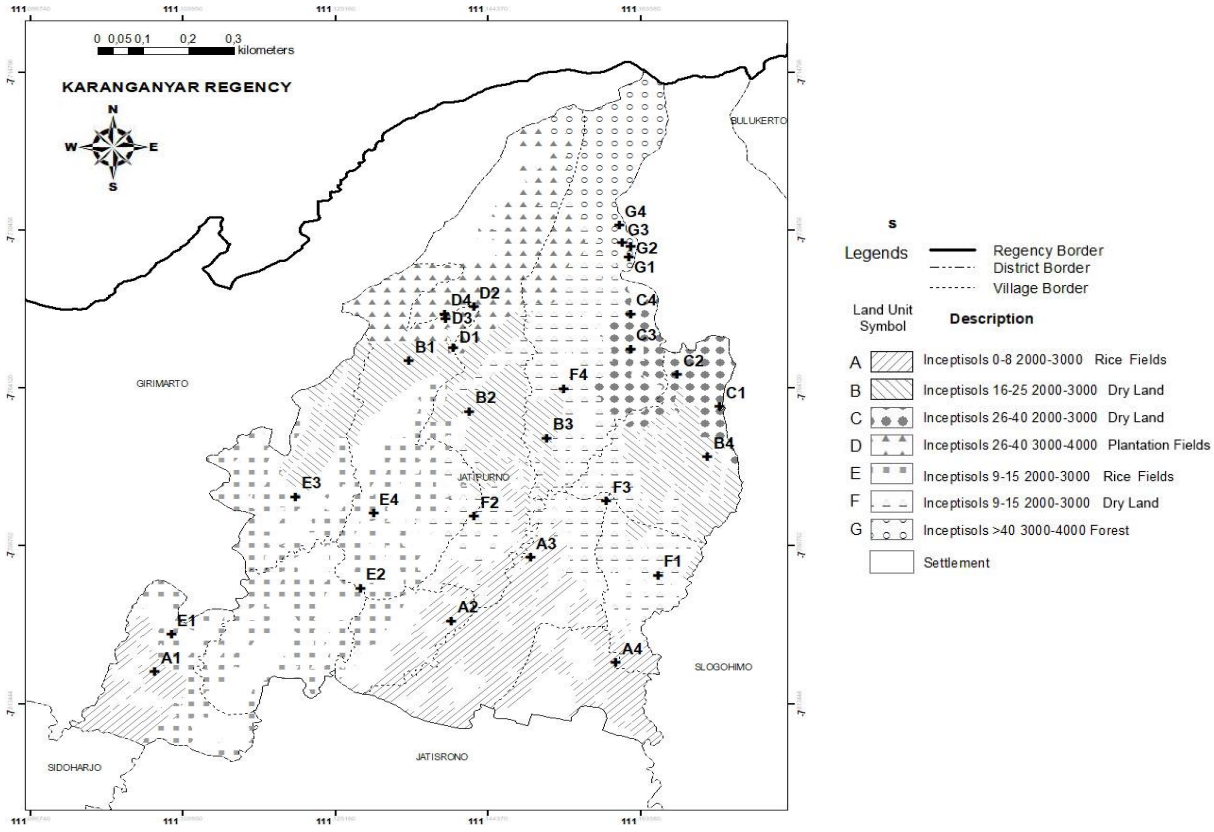


Figure 5. Map of Land Units and Sampling Points

Table 2. Quality Standard Guidelines for Soil Degradation

Parameter	Critical Threshold
Solum Thickness (cm)	< 20 %
Surface Rocks	> 40 %
Soil Texture	< 18 % colloid; > 80 % quartzite sand
Bulk Density	> 1.4 g cm^{-3}
Total Porosity	< 30 %; > 70 %
Soil Permeability	< 0.7 $cmhour^{-1}$; > 8.0 cm $hour^{-1}$
pH (H_2O) 1:2.5	< 4.5; >8,5
Electrical Conductivity	> 4.0 mS cm^{-1}
Redox	< 200 mV
Number of Microbes	< 10^2 $cfug^{-1}$ soil

Source: Indonesian Government Regulation No. 150 in 2000

Table 3. Scores of Soil Degradation Based on the Relative Frequency for Each Parameter

Relative Frequency of Soil Degradation (%)	Score	Soil Degradation Status
0-10	0	Not degraded
11-25	1	Slightly degraded
26-50	2	Medium degraded
51-75	3	Heavy degraded
76-100	4	Very heavy degraded

Source: Indonesian Government Regulation No. 150 in 2000

Table 4. Soil Degradation Status Based on the Total of Soil Degradation Scores

Symbol	Soil Degradation Status	Total Score of Soil Degradation
N	Not degraded	0
R.I	Slightly degraded	1-14
R.II	Medium degraded	15-24
R.III	Heavy degraded	25-34
R. IV	Very heavy degraded	35-40

Source: Indonesian Government Regulation No. 150 in 2000

Determining Soil Degradation Status

The Determination of soil degradation status is by using matching and scoring method, based on the relative frequency of soil degradation. Relative frequency (%) of soil degradation based on the ratio of the number of soil samples degraded to the total number of sample points in 1 unit of land/a polygon (Table 3). The sum of scores for each parameter, based on the relative frequency value, is the soil degradation status (Table 4).

RESULTS AND DISCUSSIONS

Soil degradation characteristics of research site are presented in Table 5. Table 5 shows that soil characteristics pass or below the threshold value are surface rocks value is above the critical threshold level of soil degradation at 1 point (3.57%); the soil texture value is below the critical threshold level of soil degradation at 16 points (57.14%); bulk density value is above the critical threshold level of soil degradation at 5 points (17.85%), the value of porosity is below the critical threshold level of

soil degradation at 23 points (82.14%);soil permeability value is below the critical threshold level of soil degradation at 25 points (89.28%); and the redox value is below the critical threshold level of soil degradation at 2 points (7.14%).

Solum Thickness

The results at the time of the survey (Table 5), proves that the entire Jatipurno District has a thickness value of solum above the threshold value of>20cm. The solum thickness in Jatipurno District ranges between 40cm and 150cm. So the conditions for the solum thickness in this District is not damaged. It is said that the area is still very fertile and has the availability of elements or minerals that are needed for plants to grow properly. Soil solum thickness affects the availability of nutrients or minerals needed plants to grow well. A sloping and wavy ground area, has thin depth-of-solum, due to erosion factor. Meanwhile, the flat ground area has thick solum due to sedimentation factor.

Surface Rocks

Overall surface rock samples in Jatipurno District are below 40%, only 1 point is above 40%. So for surface rocks in the Jatipurno District is not degraded. With the condition of surface rocks like this soil in the District can still be for used and properly treated for agricultural land. Surface soils dominated by rocks indicate that the area is likely to have undergone high erosion or lower soil formation rates compared to the level of soil loss. As a result, the volume of soil in the area becomes less so that the soil as a medium of biomass production becomes small. High surface rocks caused by a natural factor, which cannot be improved, such as geological condition (land topography) and soil formation. Topography is a passive factor in land forming. On a flat ground, the speed of water flow is smaller than on the wavy ground. Thus, land topography on the sloping ground has a faster process of erosion by water which affects the surface rocks.

Soil Texture

The results (Table 5) showed that colloid values in some areas of Jatipurno sub-District were below the critical threshold of <18%. So in some areas, it has a degraded status for soil texture parameter. Low colloid values of soil texture are likely caused by a natural factor, which cannot be improved. The low colloid soil texture means soil texture is too smooth and clay content is high. It affected by the low population numbers, less organism diversity living in the soil, and less organic material in the soil. In other than that it can be affected by several factors, such as humus formation, parent material type which determines soil physical and chemical properties, nutrient distribution, soil structure development, soil formation period, topography which consists of slope, height, and direction (Putri, Tati, Kusmiyarti, & Kusmawati, 2016).

Temperature and rainfall are climate elements that affect soil texture because the temperature change can cause soil-forming material weathering. It also directly influences the number of produced organic material, which will increase along with the increase of organic material's decomposition. Meanwhile, rainfall affects weathering phenomenon from factors of organic material's numbers and decomposition. If the rainfall is increasing, so that the speed of erosion.

Bulk Density

The result data showed (Table 5) that the bulk density of some areas in Jatipurno

Table 5. Data of soil degradation characteristics in Jatipurno District

No	Point	A critical threshold of land degradation									
		Solum Thickness	Surface Rocks	Soil Texture	Bulk Density	Porosity	Soil Permeability	pH	Electrical Conductivity	Redox	Numbers ofMicrobe
1	A1	120	0	16.71*	0.9	51	0.002*	7.21	0.09	100*	$5.9x10^6$
2	A2	110	2	22.99	1.1	31	0.001*	7.34	0.07	94*	$0.7x10^6$
3	A3	140	0	25.46	1.1	25*	0.002*	6.70	0.09	363	$0.3x10^6$
4	A4	80	0	19.53	1.2	28*	0.001*	6.32	0.17	530	$3.8x10^6$
5	B1	70	0	25.25	1.2	22*	0.011*	5.71	0.12	683	$0.2x10^6$
6	B2	68	1	6.52*	1.1	43	0.048*	6.33	0.07	609	$0.9x10^6$
7	B3	40	2	25.98	1.2	20*	0.001*	6.18	0.17	557	$0.5x10^6$
8	B4	70	2	8.68*	1.5	23*	0.123*	6.32	0.14	649	$6.7x10^6$
9	C1	130	5	21.07	1.2	23*	0.034*	5.78	0.17	638	$0.4x10^6$
10	C2	140	1	12.61*	1.7*	7*	6.271	5.86	0.14	664	$4.2x10^6$
11	C3	80	2	29.07	1.4	6*	0.016*	5.34	0.17	707	$1.1x10^6$
12	C4	52	2	31.80	1.0	26*	0.001*	5.53	0.15	660	$0.9x10^6$
13	D1	150	60*	8.62*	1.5	18*	0.001*	5.76	0.07	693	$1.5x10^6$
14	D2	58	2	14.70*	1.3	27*	0.031*	5.56	0.05	704	$4.2x10^6$
15	D3	90	5	16.61*	1.5	12*	0.001*	5.63	0.17	648	$27.9x10^6$
16	D4	60	5	56.40	0.9	28*	0.100*	5.52	0.05	717	$1.9x10^6$
17	E1	120	0	24.83	1.2	24*	0.001*	6.27	0.12	338	$3.9x10^6$
18	E2	60	0	24.24	1.1	26*	0.204*	6.59	0.17	289	$0.1x10^6$
19	E3	56	0	11.02*	1.4	25*	0.200*	6.61	0.13	616	$3.6x10^6$
20	E4	80	2	11.08*	1.6*	10*	0.001*	6.51	0.13	622	$2.7x10^6$
21	F1	140	0	12.21*	1.5*	17*	0.001*	6.69	0.08	694	$4.2x10^6$
22	F2	42	2	14.51*	1.3	30	0.001*	6.10	0.07	637	$0.2x10^6$
23	F3	100	1	13.16*	1.6*	13*	3.411	5.71	0.13	703	$0.8x10^6$
24	F4	80	1	13.89*	1.3	16*	0.001*	6.14	0.16	710	$1.0x10^6$
25	G1	80	5	10.71*	1.3	32	0.001*	6.44	0.07	670	$0.7x10^6$
26	G2	120	1	11.97*	1.7*	7*	1.362	6.50	0.05	672	$3.8x10^6$
27	G3	92	2	18.58	1.3	14*	0.190*	5.91	0.13	663	$1.1x10^6$
28	G4	80	0	16.40*	1.3	26*	0.001*	5.88	0.04	553	$0.4x10^6$

Source: Data Analysis; * point that passes or below the threshold value

District passes the critical threshold that is> 1.4 g cm^{-3}.density that pass the critical threshold will lead to soil density, so the soil will be difficult to loose or fertile, this will affect the ability of plant roots to penetrate the water. The bulk density varies from one point to another because of differences in organic content, soil texture, and depth of soil solum, soil fauna type, and soil moisture content. The bulk density is directly proportional to the roughness of the soil particles, the rougher it will be the greater the bulk density. It is also closely related to the degree of soil density and the ability of plant roots to penetrate water.

Porosity

Data from the research results (Table 5) shows the total porosity value in Jatipurno District mostly below the threshold value that is below 30%. So for the total porosity in the

Jatipurno Districtis degraded. With the condition of total porosity like this, the land in Jatipurno District is not good enough, this is because the land is less able to hold and absorb water. Factors affecting total porosity below the critical threshold are low unbalanced of colloid fraction and high sand-fraction, these cause the greater distribution of macropore than micropore. A dominant macro pore causes the soil to have low water absorbability and tend to have a high degree of water release.

Soil porosity, generally, is affected by soil texture, structure, and organic material in the soil. Soil with good porosity means soil with big porosity because the plants rooting will be at ease in penetrating the ground, seeking for organic material. Besides, the soil can hold rainwater, so that the plants have enough water. However, if the soil porosity is too high, materials received by the soil will be too fast down into another layer below, which is bad. This kind of soil will form big fractures in drought season. Supply of organic material and minimizing land cultivation may be practiced to overcome the problem. The effort of using organic fertilizer can also overcome high permeability (degree of water release) problem. The enhancement of soil ability in saving water and Improvement of aggregation, have an impact on the lower degree of water release.

Soil Permeability

Soil permeability is the most cause of soil degradation in Jatipurno District. The data of the research shows (Table 5) that the degree of smoothing in most areas of Jatipurno District is below the threshold value of permeability <0.7 cm hour^{-1}.This is because the soil is classified into the type of very fine particles or soil belonging to the soil clay. So that the area resulted in its watering is very slow and does not have a good water storage for plants. For paddy fields this is certainly good, but not for dry land and plantation fields because the water is difficult to seep into the soil.

The influencing factors against the soil permeability are (1) fraction composition (soil texture) if the soil texture is dominated by sand so that the soil permeability is high. It is because sand has macropores, creating fast moves of water and other materials; (2) structure, a steady-structure soil has low permeability due to small pores, while a weak-structure soil has big pores which create high permeability; (3) soil porosity, the smaller of particle size, the lower of soil permeability; (4) liquid viscosity, the higher of liquid viscosity, the smaller of soil permeability, (5) gravitation, is affecting the soil capability to bind water, the stronger gravitation, the higher of soil permeability (Suryani, Lopulisa, Nurkin, & Pairunan, 2011). The opinions are also stated by (Tolaka, Wardah, & Rahmawati, 2013) that composition of fraction is influencing against the soil ability in soil permeability, management capability, water-and-nutrients retention ability, and it is also influencing against the roots which may lead to the high soil permeability (Siregar, Sumono, & Munir, 2013).

pH

The result data (Table 5) showed that soil pH in Jatipurno District was no more than or below the threshold value of pH<4.5 to pH> 8.5. So it can be said that the soil pH in Jatipurno District is not degraded. With soil pH conditions like this, the soil in Jatipurno District is still very good and very suitable for plant growth. In soil, pH is very important in determining the activity and dominance of microorganisms in the nutrient cycle (Chaudhari, Ahire, Ahire, Chkravarty, & Maity, 2013). Soil pH values also indicate the availability of nutrients in the soil.

Electrical Conductivity

The result data (Table 5) showed that the soil electrical conductivity in Jatipurno District did not pass threshold value of electrical conductivity that is>4.0 mS cm^{-1}. So for the condition of electrical conductivity of soil in Jatipurno District not degraded. With such a soil electrical conductivity condition will not result in damage to soil structure. The Electrical conductivity describes the degree of salinity or salinity in the soil. Electrical conductivity is also a parameter that describes the ability of the ground to deliver or forward electricity from one point to another. This is caused in the ground there are elements of salt that serves as a conductor of electricity. High salt solubility in the soil may inhibit water and nutrient uptake by plants due to osmotic pressure (Nur Abdulkarim A, Sariffuddin, & Yuda Ardiansyah, 2015).

Redox

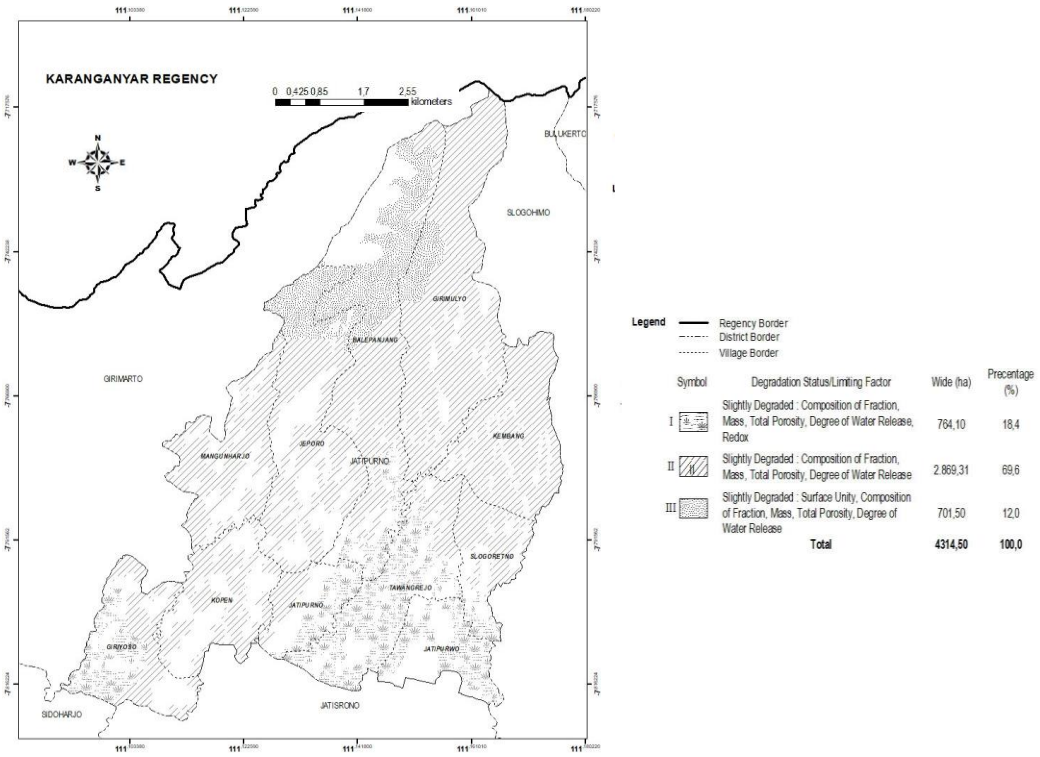
The data of the research (Table 5) shows that the redox of the entire Jatipurno District has a value below the threshold value of <200 mV. So that the redox of land in Jatipurno District is declared not damaged. This is because the soil condition is still classified into low potential redox whose impact is the soil becomes fertile. High redox potential values usually occur in soils that have good aeration and more oxygen in the soil solution so that more oxidized compounds. Whereas low-potential redox occurs in soil lack of oxygen so that many compounds are reduced (Syekhfani, 2014).

A factor affecting redox is activities of microorganism. The low value of redox in soil shows the condition of the reductive soil. This condition is usually in relation to bad drainage or a condition which soil contains too much water (Shangguan, Dai, Liu, Ye, & Yuan, 2012). Potential redox affects N status in the soil; the availability of P and Si; directly affects levels of Fe^{2+}, Mn^{2+}, and SO_4^{2-}; and indirectly affects levels of Ca^{2+}, Mg^{2+}, Cu^{2+}, Zn^{2+}, and MoO_4^{2-}; decomposed organic material and H_2S. The soil mass if affected by the size amount of pore space in the soil. The bigger of soil's pore space, the smaller of the soil mass.

Numbers of Microbe

The result of the research shows that the number of microbes in Jatipurno District is below the critical threshold that is $<10^2 CFUg^{-1}$ so the total number of microbes in JatipurnoDistrict is not degraded. This is because the soil in Jatipurno District is good enough with the condition of soil whose physical, chemical and biological properties support in microbial development. Microbes in the soil are very helpful in the process of decomposition of organic materials. The amount and variety of microbes depend on the amount and composition of the overhauled material, pH, moisture, aeration, and other environmental conditions (Budiyanto, 2014). The existence of total microbes can also describe the quality of the soil. The higher the total number of microbes indicating the atmosphere of both chemistry and physics in the soil is very supportive.

Several attempts to reduce the adverse effects arising from the above limiting factors are the provision of organic matter to the soil, increasing the fertility of the soil. Organic materials in the soil, will add clay properties and reduce the bad sand properties, such as the ability to save water, improve soil aggregation and increase the capacity of cation exchange. Efforts to use organic fertilizers can also overcome the factors that affect the low soil permeability. Poor land management resulting in higher levels of soil erosion, which leads to a high level of surface rocks can be overcome by preventing and



Symbol	Degradation Status/Limiting Factor	Wide (ha)	Precentage (%)
I	Slightly Degraded : Composition of Fraction, Mass, Total Porosity, Degree of Water Release, Redox	764,10	18,4
II	Slightly Degraded : Composition of Fraction, Mass, Total Porosity, Degree of Water Release	2.869,31	69,6
III	Slightly Degraded : Surface Unity, Composition of Fraction, Mass, Total Porosity, Degree of Water Release	701,50	12,0
	Total	**4314,50**	**100,0**

Figure 6. Map of Soil Degradation Status in Jatipurno District

improving conservation techniques, such as improved terraces on slopes.

In addition to planting variations of cover crops, on land plots (low, medium, high cover crops), land management by crop rotation and intercropping, minimum tillage in accordance with the rules of environmental conservation, can be done to minimize the soil degradation.

Soil degradation Status Determination in Jatipurno District

The distribution of soil degradation parameter data, in Jatipurno District, is tabulated, classified, and analyzed to obtain relative frequency, score, and numbers of the score, soil degradation status and limiting factors, and presented in Table 6. Soil degradation status in all areas is slightly degraded (R.I.) as seen in Table 6. In unit A land parameters which are above the degradation threshold value or as a limiting factor is bulk density, and parameters which are below the degradation threshold value or as a limiting factor are soil texture, total porosity, soil permeability and redox with total score 13 and 691.46 ha of soil degradation status at slightly degraded. In unit Bland, parameters which are above the degradation threshold value or as a limiting factor is bulk density and parameters which are below the degradation threshold value or as a limiting factor are soil texture, total porosity, soil permeability with total score 12 and 632.88 ha of soil degradation status at slightly degraded. In unit C land, parameters which are above the degradation threshold value or as a limiting factor, is bulk density and parameters which are below the degradation threshold value or as a limiting factor are soil texture, total porosity, soil permeability, with total score 11 and 464.88 ha of soil degradation status in slightly degraded. In unit D land,

parameters which are above the degradation threshold value or as a limiting factor, are surface rocks and bulk density and parameters which is below the degradation threshold value or as a limiting factor are soil texture, total porosity, soil permeability, with total score 14 and 739.18 ha of soil degradation status in slight degraded.

In unit E land, parameters which are above the degradation threshold value or as a limiting factor is bulk density and parameters which are below the degradation threshold value or as a limiting factor are soil texture, total porosity, soil permeability with total score 13 and 727.34 ha of soil degradation status in slightly degraded. In unit Fland, parameters which are above the degradation threshold value or as a limiting factor, is bulk density and parameters which are below the degradation threshold value or as a limiting factor are soil texture, total porosity, soil permeability, with total score 12 and 715.34 ha of soil degradation status at slightly degraded. In unit G land, parameters which is above the degradation threshold value or as a limiting factor, is bulk density and parameters which is below the degradation threshold value or as a limiting factor are soil texture, total porosity, soil permeability, with total score 12 and 343.31 ha of soil degradation status in slightly degraded.

Based on Table 6 Soil Degradation Status Based on Land Unit above, Jatipurno District has soil degradation status of slightly degraded, with 764.10 ha (18.40%) of land has limiting factors of composition fraction, mass, total porosity, the degree of water release and redox, in sub-districts of Jatipurwo, Jatipurno, Giriyoso, Slogoretno, Tawangrejo and Balepanjang.

Table 6. Total ScoresAnd Soil Degradation Status Based on Land Unit

Land Unit	Total Score	Degradation Status	Area (ha)	Symbol	Limiting Factor
A	10	Slightly Degraded	764.10	R.I	The Texture is too smooth(clay content is high), high Bulk Density, Total Porosity is low, Soil Permeability is low, Redox is low
B	10	Slightly Degraded	625.88	R.I	The Texture is too smooth(clay content is high), high Bulk Density, Total Porosity is low, Soil Permeability is low
C	9	Slightly Degraded	454.98	R.I	The Texture is too smooth(clay content is high), high Bulk Density, Total Porosity is low, Soil Permeability is low
D	14	Slightly Degraded	701.50	R.I	Surface Rocks is high, The Texture is too smooth(clay content is high), high Bulk Density, Total Porosity is low, Soil Permeability is low
E	11	Slightly Degraded	720.34	R.I	The Texture is too smooth(clay content is high), high Bulk Density, Total Porosity is low, Soil Permeability is low
F	12	Slightly Degraded	708.34	R.I	The Texture is too smooth(clay content is high), high Bulk Density, Total Porosity is low, Soil Permeability is low
G	10	Slightly Degraded	336.31	R.I	The Texture is too smooth(clay content is high), high Bulk Density, Total Porosity is low, Soil Permeability is low

Description: Each land unit is repeated four times or represented with four points, thus every parameter above the quality standard, has 100%-valued relative frequency and score 4, while parameter below the quality standard, has 0%-valued relative frequency and score 0

Meanwhile, 2,869.31 ha (69.60%) of land has limiting factors of the composition of a fraction, mass, total porosity, and degree of water release in sub-districts of Jatipurno, Giriyoso, Kopen, Slogoretno, Tawangrejo, Kembang, Mangunharjo, Girimulyo, Balepanjang, and Jeporo. 701.50 ha (12.00%) of land with limiting factors of surface rocks, the composition of a fraction, mass, total porosity, the degree of water release in sub-districts of Mangunharjo, Girimulyo, Balepanjang, and Jeporo.

CONCLUSION

Soil degradation status in Jatipurno District all is slightly degraded with limiting factors are high surface rocks, the soil texture is too smooth (clay content is high), high bulk density, low total porosity, low soil permeability, and low redox. The application of organic material to the soil, conserve the land both mechanically and vegetatively and minimum tillage, may overcome and minimize the limiting factors.

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