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Assesment of land biophysical properties on different slope positions as management conservation sustainable in Districts of North Moramo, South Konawe, Indonesia

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A field research was conducted in disctrict of North Moramo, South Konawe Indonesia aimed to study the characteristic of land on different slope positions (upper slope, middle slope, bottom slope) as optimization and sustainable management directions. The results showed that; (1) climatic conditions in the research location are classified as semi-humid climate type B (Schmidth-Fergusson) with >8 wet month and 2 dry month with Q value = 23.53%, type of agroclimate D1 (Oldeman) with 3 wet month and 1 dry month, annual rainfall average as 2.286 mm year^{-1}; (2) vegetation type and soil characteristic are different for each slopes position. The optimization and land management techniques were recommended implementing vegetative land conservation as an effort to restore soil quality towards sustainable agriculture and forestry development.

Keywords:Suboptimal land, slope different, land characteristic, vegetatif conservation method

INTRODUCTION

The North Moramo is one of sub-districts in South Konawe Regency which is dominated by agro-ecosystem of dry land suboptimal and still quite wide (BPS Konsel, 2016; BPS Moramo Utara, 2016) so it has significance in Agricultural and Forestry Development in Indonesia. However, besides the slopes of land also information about other limiting factors is still lacking, because there are variability of soil properties based on space and time as a consequence of variation of soil material and micro climate. For effectiveness and efficiency in agriculture and forestry development require application of development principles according to variability of land characteristic, so there is need for assessment to estimate and mapping the spatial variability of soil properties to be developed (Zhao et al.2007).

The agricultural and forestry development can only be sustainable if in land management practice simplement conservation-based technologies based on soil characteristics and local climatic conditions (Arsyad, 2010;Baja, 2012). The land not only serves as a place for the growth of crops, the provision of nutrients for plants and foot holds but also its function as a part of the ecosystem, can even be a separate ecosystem. Decreased soil function can cause disruption of the surrounding ecosystems such as vegetation type even including humans (Waluyaningsih, 2008).

Increased productivity of suboptimal land for agricultural and forestry activities and natural conservation can be done by modifying the land environment (Subiksa, 2002; Baja, 2012; Kandari et al. 2013; Kandari et al. 2014; Kandari et al. 2015). The land with a slope above 15% if the soil is not well managed or planted, it is very vulnerable to erosion in the rain. This happens because the soil is unable to absorb rain water into the soil, so it happens run off which washes away the grains of soil that caused the soil to degrade and become infertile even the management will not be sustainable.

MATERIALS AND METHODS

Research Set up

Field research was conducted in Mekar Jaya village, disctrict of North Moramo, South Konawe Indonesia, with geographical location at 04^{o}06'22"-04^{o}07'40" LS and 122^{o}34'41"-122^{o}35'27"EL. Initial data collection conducted on November until December 2014, sampling and laboratory analysis conducted on January untill July 2015, assessment and overlay analysis on September untill December 2016.

Research of Methods and Data Collection

The research methods were adapted for the purpose of use, i.e.: (1) the climatic characteristics were analyzed using the tabulation method and displayed the results using graphical methods (air temperature and humidity) and histogram methods (rainfall), and Oldeman and Schmidth-Fergusson methods to determine the climate type; (2) vegetation type, observed by vegetation guidance, (3) soil characteristics, including: (a) soil morphology, using profile extracting method, (b) soil texture, using pipette method; (c) soil pH (pH H_2O and pH KCl) using pH meter; (d) Cation Exchange Capacity (CEC), using saturation of ammonium acetate; (e) organic matter, using Walkey and Black method; (4) suggested conservation techniques, analyzed by over laying methods based on climatic characteristics, soil characteristics, soil developments in accordance with assessment techniques (Departemen Pertanian, 2006) as presented in Table 1 and 2.

Table1. Biophysical factor correlation score and landslide sensitivity level on mountain land

Biophysical factors	Value (Score)		
Rainfall (mm)	< 1.500 (1)	1.500 – 2.500 (3)	> 2.500 (5)
Parent material	Volcanic rock (1)	Metamorphic rocks (2)	Sedimentary rocks (3)
Slopes (%)	15 – 25 (1)	25 – 40 (3)	> 40 (5)
Clay content 2:1	Low (1)	medium (2)	high (3)
Infiltration rate	slow (1)	medium (2)	fast (3)
Water proof layer depth (cm)	> 100 (1)	50 – 100 (2)	< 50 (3)

Notes: the number in brackets states a score for climate and soil characteristics in the local area (Departemen Pertanian, 2006)

Table2. Guidelines for the selection of soil conservation technology mechanically and vegetative based on land slope, soil erodibility, and depth of solum (P3HTA has been modified)

Slope (%)	> 90		40 – 90 cm		< 40 cm		Recommended Plant Proportion (%)	
	Low	High	Low	High	Low	High	a season	Annual
15 - 25	TB,BL,	TB,BL,	TB,BL,	TB,BL,	TB,BL,	TB,BL,	Maximum 50	Minimum 50
	PH,SP,	PH,SP,	PH,SP,	PH,SP,	PH,SP,	PH,SP,		
	PT,RR,	PT,RR,	PT,RR,	PT,RR,	PT,RR,	PT,RR,		
	ST	ST	ST	ST	ST	ST		
> 25 - 40	TB, BL,	TG, BL,	TG, BL,	TG, BL,	TG, BL,	TI,RR,	Maximum 25	Minimum 75
	PH, PT	PH, PT	PH, PT	PH, PT	PH, PT	BL, PH, PT		
> 40*	TI, TK	TI, TK	TI, TK	TI, TK	TI, TK	TI, TK	0	100

*Notes: For erosion-sensitive soils (Ultisol, Entisol, Vertisol, Alfisol) are limited to 65% slope, whereas for less sensitive soils up to 100% slopes, TB = Terrace bench; BL = Aquaculture hall, TG = Terrace gulud; TI = Individual Terrace; RR = Rorak; TK = garden terrace, PH = live fence; ST = Strip of grass or strip of natural plant; SP = Silvipastura; PT = Soil cover crop. * = Departemen Pertanian, 2006*

Observation Variables

The variables observed were: (1) climate characteristics during the last 10 years; (2) vegetation types; (3) physical soil properties at different slope positions (upper slope, middle slope, and bottom slope).

RESULTS AND DISCUSSION

Climate Characteristics

The climate characteristics in the research area especially rainfall are relatively fluctuating, where the highest monthly rainfall occurred in March as 299.4 mm and the lowest in September as 62.11 mm with an average annual rainfall as 2,286.33 mm, according to Oldeman (1979) agroclimate D1 with 3 wet month (March, April, May) and 1 dry month (September), and according to Schmidth and Ferguson (1951) classified climatic type B with rates wet month 7.25 mm, rates drymonth 1.58 mm and Q value is 21.79%. The average of air temperature is 26.74^{o}C, the highest occurring in March (27.7^{o}C) and the lowest in July (24.9^{o}C), while the average air humidity in the study area is 80.53%, the highest in June (84.5%) and the lowest in October (75.0%). This fact indicates that the region is an important thing that must be considered both in the position of the upper and lower slopes, especially in the position of the middle slope due to higher slope rate. The results of climate data analysis, especially rainfall, air temperature, and air humidity based on observations around the research area during the last 10 years (2005-2015 periods) showed in Figure 1.

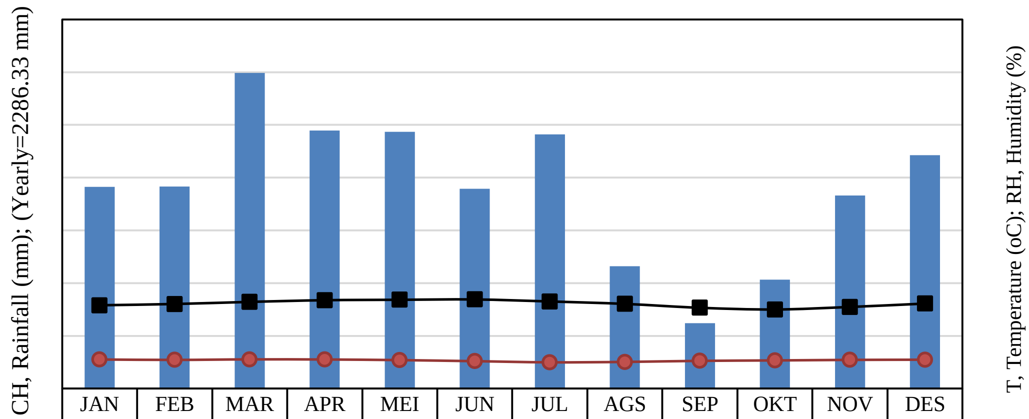
The results of research indicating that the condition of North Moramo climate is classified as semi-humid climate type with annual rainfall >2000 mm per year, the chance of soil damages due to run off and soil erosion becomes an important issue that must be paid attention especially in its relation to soil condition that slope either position of slope upper, middle and bottom because it can affect the quality of land that impact to crop productivity in management both for food crop development and forestry. It is in accordance with the statement (Backlund et al.2008) that climate conditions greatly affect forest productivity, species composition, frequency and magnitude of disturbance. It further argued that the impact of changes in precipitation and temperatures is likely to decrease the effect of vegetation cover that protects the soil surface from wind and water erosion. The intensity of rainfall and the slope of the slope determine the rate of ground loss at a site (Martono, 2004. The intensity of rainfall is very influential in controlling the size of soil damage caused by erosion (PPTA, 2003; Huang et al. 2012) and the soil with higher of slope degrees can be more easily disturbed or damaged, especially if rainfall conditions are of high intensity (Zhu et al. 2014).

Vegetation Types

From three points ofobservation on each slope position, vegetation types of different species are found, where in the PLA there are types of grassland type vegetation not found in PLT and PLB, and in PLA there is no type of grassland but there are in PLT and PLB. In PLT there is a type of pandanus forest not found in PLA and PLB. In the PLB was dominated by the type of grassland and there is also in the PLT but it is not found in the PLA (Table 3).

The presence of vegetation was found to be relatively different at three slope positions observed because of different soil conditions and even suspected presence of vegetation influenced soil characteristics in each slope position. This opinion is consistent with the previous researcher's assertion that the type of vegetation covering the soil has been widely recognized as one of the best indicators for determining soil conditions, where soil conditions are often assessed and monitored according to vegetation cover and variations in time and space (Booth and Tueler, 2003). The vegetation cover on a different land at a certain slope may contribute to retaining rain water that falls on the surface so that it can reach deeper into the ground. The state of vegetation in the form of forests on hilltops and steep backs will be a dampening fluctuation of water flow between the rainy season and the dry season. In addition, it will maximize the hydrological function of the area as water storage. However, in the lower slopes, forest has generally turned into agricultural land (Huang et al. 2012)

. The vegetation plays an important role in protecting the soil from erosion, where its effectiveness in suppressing surface flow and erosion is influenced by vegetation type, canopy height, crown area, vegetation density and root density. Naturally, the existence of both heterogeneous and homogeneous vegetation is the most effective form of land cover to reduce the possibility of erosion, because with the rain water vegetation relatively stifled so that its ability to absorb water into the soil is quite good. The land clearance phase begins with a suitable land selection for the location of the farm.



	JAN	FEB	MAR	APR	MEI	JUN	JUL	AGS	SEP	OKT	NOV	DES
CH (mm)	191.3	191.5	299.4	244.6	243.4	189.4	241.1	115.9	62.1	103.2	183.2	221.4
T (oC)	27.6	27.2	27.7	27.6	27.0	26.0	24.9	25.3	26.3	26.7	27.2	27.4
RH (%)	79.0	80.2	82.2	83.8	84.2	84.5	82.6	80.3	76.6	75.0	77.4	80.6

Figure1. Fluctuations of rainfall (CH), temperature (T), and humidity (RH) around the research of area

Table 3. The vegetation types at three different slope position

Sample	**Vegetation Types in Different Slopes**		
	Upper (PLA)	**Middle (PLT)**	**Bottom (PLB)**
1	Grassland	Forest 1 (eha tree, songi tree, ruruhi tree)	Forest 1 (songi tree, ruruhi tree)
2	Forest 1 (songi tree, eha tree)	Forest 2 (ruruhi tree, rattan, pandanus	Grassland 1
3	Forest 2 (ruruhi tree, rattan)	Grassland	Grassland 2

The land is selected based on its fertility with indicator of vegetation diversity, soil depth, and the amount of soil attached to the stone (Jafari et al. 2014).

Physical Properties

The soils in PLA, PLT, and PLB generally have the same physical properties, generally textured dust clays (SiL), except for layer I clay (CL) clusters on PLA with forest vegetation, PLT and PLB with grassland vegetation. The highest average content weight in PLT (1.47 g cm^{-3}) relatively the same as PLB (1.46 g cm-3), and the lowest onthe PLA (1.2 g cm^{-3}). The highest of content ground water content in PLT (19.93%), PLT (15.26%) and the lowest on the PLB (11.71%). The highest of average porosity of land in the PLA (53.14%) and the lowest on the PLB (45.02%) which is relatively the same as in PLT (44.64%). This fact indicates that the slope position and the presence of vegetation are not significant effects on soil physical properties (Figure 2).

Figure 2 showed that there is no significant relationship pattern between porosity, moisture contents and weight of contents due to slope position difference. However, it is interesting that the type of vegetation affects the fluctuation of soil water content so that it is assumed to affect the level of soil development as a consequence of the role of water content as a slurry agent where the slope position and the soil layer that has high moisture content of vegetation will soon be obsolete the development of the land is relatively young. The results of research on the ratio of dust and clay in the study sites show that starting from the upper slope to the bottom slopes indicates a relatively high dust and clay ratio which means that the dust fraction is more dominant than the clay fraction (Table 4 and Figure 2).

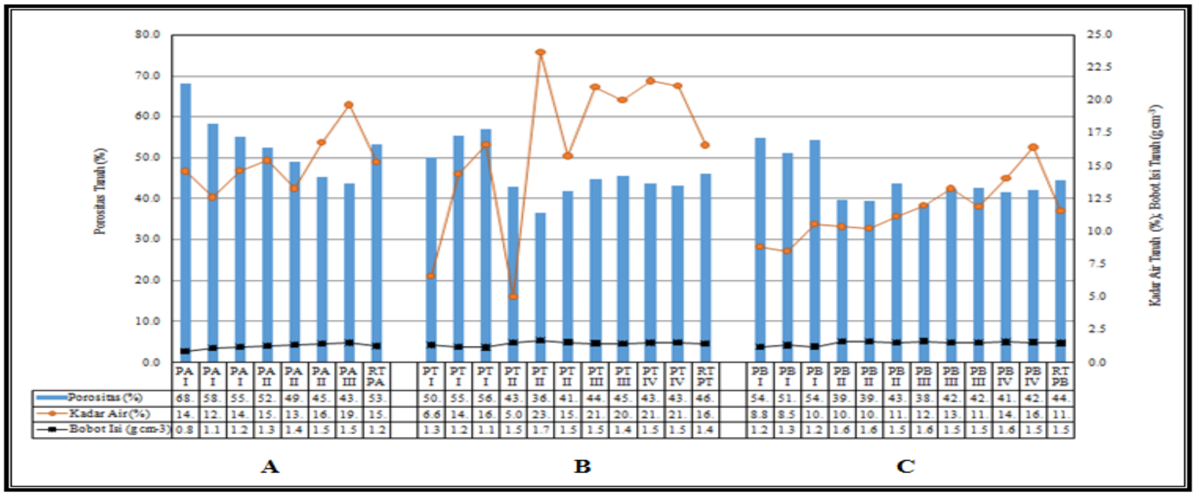


Figure 2. Spreading of porosity value (%), moisture content (%) and weight of land content (g cm^{-3}):

A. On the Upper slope position, layer of soil I – III (PA I, II, III)
B. On the middle slope position, layer of soil I – IV (PA I, II, III, IV)
C. On the bottom slope position, layer of soil I – III (PA I, II, III, IV)

This fact indicates that the weathering intensity at the study site is very slow because it is still dominated by the dust fraction. The opinion is relevant to the statement Jackson et al. (2007), that the soil weathering rate can be measured from the ratio of dust and clay, especially the developing soils of the same parent material. Furthermore it is argued that the higher percentage of dust and clay ratio indicates less intensive weathering intensity vice versa if the high dust and clay ratio value describes the intensity of weathering which is quite intensive.

From the result of the research indicating the difference of pattern of the distribution of soil fraction in each slope position, indicates that the process of pedogenesis runs is not the same, besides because of the difference of environmental factors. This may be due to the vegetation type due to different land uses and slope positions so that soil particles become different based on different types of land use vegetation and slope positions. The soil profile formed on the upper slopes appears to be undeveloped characterized by each layer in the formed profile dominated by the dust fraction and increased dust and clay decrease in each layer formed from the top layer to the bottom layer. The development of soil from aging young lands on the middle slopes is relatively inhibited, as it is closely related to the process of soil erosion and surface aliances that bring the soil to the lower slopes so that the soil is slow to develop. In addition, the slope position on the middle slope causes the movement of water to the lower slopes faster than the movement of water into the soil layer, so water as a non-intensive agentia in destroying the parent material to form the soil (Yulina et al. 2015).The intensity of weathering in addition to being influenced by climate and parent rock is also influenced by topographic diversity. The role of topography to weathering intensity and level of soil development is indicated by the diversity of soil characteristics generated on each soil profile formed on topographic diversity from the upper slopes to the lower slopes (Alam et al., 2011; Yulina et al. 2015).

The other physical properties, i.e.: moisture content and weight of the soil content are greater at the lower slope position than the upper and middle slopes, since the slope position also influences the large surface flow, where water flows from the upper slopes (PLA) to the middle slope (PLT) and (PLB) so that water accumulates on the bottom slopes and automatically increases ground water content. The opinion is also in accordance with the statement (Hardjowigeno, 2003) that the soil destroyed by the collision of rain water, then will be transported by the surface flow from the upper slopes to the central and lower slopes, so that on the bottom slope

Table 4.Characteristic physical properties of soil at different slope positions in district of North Moramo South Konawe Regency

Vegetation Types	Soil Layer	Characteristic Physical Properties of Soil							
		Moisture (%)	Content weight(g cm^{-3})	Porosity (%)	Size Distribution (%)				Ratio Dust/Clay
					Sand	Dust	Clay	Class	
----------------------------- Upper Slope Position (PLA) ------------------------------									
Forest 1	I	14.58	0.84	68.17	43.50	24.64	31.86	CL	0.77
	II	15.41	1.26	52.43	9.76	66.97	23.27	SiL	2.88
Sub Average:		15.00	1.05	60.30	26.63	45.81	27.57		1.83
Forest 2	I	12.60	1.11	58.26	24.83	46.76	24.83	SiL	1.88
	II	13.25	1.35	48.95	14.36	59.12	26.52	SiL	2.23
Sub Average:		12.93	1.23	53.61	19.60	52.94	25.68		2.06
Grass	I	14.62	1.19	55.03	22.60	51.47	25.93	SiL	1.98
	II	16.76	1.45	45.36	6.95	71.08	21.97	SiL	3.24
	III	19.63	1.49	43.80	3.50	76.51	19.99	SiL	3.83
Sub Average:		17.00	1.38	48.06	11.02	66.35	22.63		3.02
Average:		15.26	1.24	53.14	17.93	56.65	24.91		2.40
----------------------------- Middle Slope Position (PLT) ------------------------------									
Forest1	I	6.59	1.32	50.02	5.82	69.68	24.51	SiL	2.84
	II	5.01	1.51	43.00	3.36	72.63	24.01	SiL	3.02
Sub Average:		5.80	1.42	46.51	4.59	71.16	24.26		2.93
Forest 2	I	14.36	1.18	55.43	19.2	54.66	26.14	SiL	2.09
	II	23.67	1.68	36.44	5.44	70.78	23.78	SiL	2.98
	III	21.02	1.46	44.84	4.11	72.56	23.30	SiL	3.11
	IV	21.45	1.49	43.64	3.38	73.92	22.70	SiL	3.26
Sub Average:		20.13	1.45	45.09	8.03	67.98	23.98		2.86
Grassland	I	16.62	1.14	56.92	36.57	35.41	28.02	CL	1.26
	II	15.75	1.54	41.88	8.31	69.9	21.79	SiL	3.21
	III	20.00	1.44	45.61	3.64	76.32	20.04	SiL	3.81
	IV	21.00	1.51	43.16	2.61	77.77	19.62	SiL	3.96
Sub Average:		18.34	1.41	46.89	12.78	64.85	22.37		3.06
Average:		19.93	1.47	44.64	9.15	68.09	22.75		3.08
----------------------------- Lower Slope Position (PLB) ------------------------------									
Grassland 1	I	8.82	1.20	54.75	17.11	56.18	26.70	SiL	2.10
	II	10.36	1.59	39.82	6.82	70.56	22.62	SiL	3.12
	III	11.93	1.63	38.52	3.39	74.93	21.68	SiL	3.46
	IV	14.02	1.55	41.67	0.53	78.60	20.87	SiL	3.77
Sub Average:		11.28	1.49	43.69	6.96	70.07	22.97		3.11
Grassland 2	I	8.51	1.30	51.07	35.33	33.02	31.65	CL	1.04
	II	10.22	1.61	39.41	13.53	62.38	24.09	SiL	2.59
	III	13.26	1.53	42.25	6.50	70.66	22.84	SiL	3.09
	IV	16.39	1.54	42.01	5.45	73.01	21.54	SiL	3.39
Sub Average:		12.10	1.50	43.69	15.20	59.77	25.03		2.53
Forest 2	I	10.57	1.21	54.22	20.98	50.83	28.18	SiL	1.80
	II	11.12	1.50	43.58	10.24	66.36	23.39	SiL	2.84
	III	11.88	1.53	42.62	8.10	67.62	24.27	SiL	2.79
Sub Average:		11.19	1.41	46.81	13.11	61.60	25.28		2.48
Average:		11.71	1.46	45.02	14.30	60.55	25.14		2.51

Notes: CL = Clay, SiL= Dusty Clay

occurs the deposition of soil material from the upper slopes, the destruction of the soil, and transport. On the other hand, there is an output on the upper slopes due to transport. It further argued that the vertical movement of water can dissolve soil materials to cause soil ingredients to decline as well as accumulate on the lower slopes of which the ground water content and the weight of the soil content also increase.

This fact indicates that the soil porosity portion which describes the volume of soil unfilled by solids in both mineral and organic material will decrease from the upper slopes to the lower slopes. The difference of the slopes also causes differences in the amount of water available to the vegetation that affects the growth of vegetation in the place.

CONCLUSION

Based on the results of research and discussion that has been described, concluded as follows: (1) Location of research in North Moramo District South Konawe Regency is relatively wet climate, with average annual rainfall characteristic 2,286.33 mm year^{-1}, D1 has agglomerate type (Oldeman) and Cl (B-Schmidth-Ferguson) climate type with flat air temperature 26.74^{o}C, and air humidity averaged 80.53%. (2) At the top slope position (PLA) includesforest and grass vegetation types, on the central slope position (PLT) covering forest and grassland vegetation types, whereas in the lower slope position (PLB) dominant type of grassland. (3) Characteristics of soil at upper slope position (PLA), mid-slope position (PLT), and slope downward position are relatively different although developed on the same parent material and climate. (4) Vegetative conservation technique is an appropriate choice especially in the position of the central slope (PLT), especially in maintaining the stability of soil development and maintaining the stability of groundwater and soil organic matter, including PH= live fence, ST= Strip of grass or strip of natural plant, PT= Soil cover crop, and BD= Aquaculture. (5) The vegetative conservation, it is also advisable to develop deep-rooted forestry crops with a combination of aquaculture cultivation system in an effort to optimize suboptimal land use in the research area.

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CONFLICT OF INTEREST

The authors declared that present study was performed in absence of any conflict of interest".

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AUTHOR CONTRIBUTIONS

Aminuddin Mane Kandari and Syamsu Alam designed and performed the experiments, analyzed and interpreted data. Muhidin and Halim were wrote the manuscript. Yuswandi was assisted in the retrieval of field research for data. All authors read and approved the final version.

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