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Conventional land management of agro-forestry in different slope positions based on soil chemical properties in Districts of North Moramo, South Konawe Indonesia

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This research conducted in disctrict of North Moramo, South Konawe Indonesia was aimed to study the characteristics of soil chemical properties on different slope positions as conventional land management of agro-forestry. The stages of research: (1) preparation; including literature study and secondary data collection, (2) making of field work map in scale 1:10.000 based on information from thematic maps and based on the extent of slope spread in district of North Moramo and (3) field observation including pre-survey, the main survey, excavation of profiles at each slope position to the parent material layer and soil sampling at each slope position to be analyzed in the laboratory to describe the soil chemical properties.The variable observation include: (a) soil morphological properties; (b) soil chemical properties and(c) alternative conservation method. The result of research showed that's the pH value of the three slope positions in the study location was generally classified as low (sour), cation exchange capacity (CEC) was low (5-16.99 me 100 g^{-1}) to very high categories (>40 me 100 g^{-1}). The highest soil CEC value is found in the profile of the middle slope (PLT) with forest vegetation 2 (47.35 me $100g^{-1}$) and the lowest is in the profile of the lower slope (PLB) with grasses (13.31 me 100g-1), conservation techniques according to the location of the research especially at the position of the middle slope i.e.; structured vegetative technique (PH = living fence, ST = grass strip or natural plant strip, PT = cover crop, and BD = aisle cultivation).

Keywords: agro-forestry, natural plant strip, slope, soil chemical

INTRODUCTION

The agriculture and forestry development are two sectors that are very strategic and a serious concern from all countries in the world, especially those with natural resources and the potential to increase land productivity, income and welfare of the community so that the managements must be sustainable (World Bank, 2010; Gimenez et al., 2015; GFR, 2015). The soil is an effective medium for the growth of agricultural crops and forestry composed by layers that are dynamic and easy to degrade, so that it can change from optimal to suboptimal mainly influenced by topography and climate conditions (Zhu, 2013;Lawal et al., 2014).

The topography is closely related with the weathering intensity and level of soil development as indicated by the diversity of soil characteristics on each soil profile from the upper slope to the bottom slope (Brady and Weil, 2002; Hardjowigeno, 2003; Esu et al., 2008; Akbaril et al., 2014; Yulina et al., 2015). The magnitude of the climatic effect on the weathering intensity and the progression of the soil profile depend on the amount of rainwater capable of passing through the soil or the occurrence of a large evaporation that causes ground water to rise from the deepest layer of soil or from the groundwater surface (Sutanto, 2005). The soils with greater slope degrees can be more easily disturbed or damaged, especially if rainfall conditions are of high intensity. It is further explained that in an agro-ecosystem, the slope of the soil with >15% and high rainfall can cause landslides (Arsyad, 2010; Zhu et al., 2014).

The vegetation plays an important role in protecting 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 (Morgan, 1979; Jafari et al.,2014). The factors that influence the amount of surface flow and erosion are the physical condition of the environment including climate, watershed shape, topography, and land use pattern (Arsyad, 2010).

MATERIALS AND METHODS

Research Set up

The stages of research: (1) preparation; including literature study and secondary data collection; (a) Indonesia earth map in Scale 1:50.000 Moramo sheet, (b) geological map with Indonesian system in scale 1:250.000Kolaka Sulawesi sheet, (c) map of administration disctrict of North Moramo in scale 1:50.000, (d) climate component data in 2005-2015. (2) Making of field work map in scale 1:10.000. (3) based on information from thematic maps and based on the extent of slope spread in district of North Moramo.

Stage of Field Research

The stage of field research or observation including pre-survey, observed along the dominant slope of the study site, and determined three slope position boundaries, ie; the top slope position at the top, the central slope located at the center of the slope and the lower lowers slope at the bottom. At each position the observation of the vegetation type and code point of the profile hole is made. In each position the observation of the vegetation type and codes the point of making the profile hole.)

The main survey, validating slope positioning, ie; upper slopes based on the location of the upper slopes that did not add material from the erosion process, the center of the slope was determined by the steepest slope while the lower slope was determined on a flat slope.Excavation of profiles at each slope position to the parent material layer, the observations are made based on the internal and external profile card to describe the physical characteristics and the soil morphology.The soil sampling at each slope position to be analyzed in the laboratory to describe the properties soil chemistry; (e) Observations descriptively observation, conducted to describe visually the environmental conditions of the study sites, both soil conditions and vegetation at each position of different slopes.

The phase of assessment and analysis of overlay between climate characteristic, vegetation type, soil characteristics, soil development condition with some land conservation techniques, using assessment method from (DepartemenPertanian, 2006) i.e.: (a) scoring the relationship of biochemical factor and level landslide sensitivity on sloped land; (b) guidelines on the selection of soil conservation technologies mechanically and vegetative based on land slope, soil erodibility and depth of solum.

Observation Variable

The variable observation include: (a) soil morphological properties; (b) soil chemical properties and alternative conservation method.

RESULTS

Soil Morphological Properties

In the PLA there are three layers and three horizons (A, AB, and B) with maximum effective depth of 43-50 cm, PLT there are four layers and five horizons (A, AB, B1, B2, and B3) with maximum effective depth of 95-115 cm, and on the PLB there are four layers and six horizon (A, AB, B1, B2, B3, and BC) with effective depth of 95-105 cm.

The result of research appears that there are differences in the appearance of soil morphological properties at different slope positions in terms of number of layers, horizon, horizontal thickness, or soil color (Table 1).

Table1; Soil morphological properties in different slope

Vegetation types	Layer	Soil Morphological Properties			
		Horizon	Horizonthickness (cm)	Structure	Color
Upper Slope Position (USP)					
Forest 1	I	A	0-12/14	Sb	Very brown 10 YR 7/4
	II	AB	12/14-29/34	Sb	Brownish yellow 10 YR 6/6
Forest 2	I	A	0-14/19	Sb	Yellow 10 YR 8/8
	II	AB	14/19-44/63	Sb	Yellowish red 7,5 YR 8/6
Grassland	I	A	0-13/16	Sb	Light gray 10 YR 7/2
	II	AB	13/16-33/40	Ab	Yellowish red 7,5 YR 6/8
	III	B	33/40-43/50	Sb	Yellowish red 7,5 YR 7/8
Middle Slope Position (MSP)					
Forest 1	I	A	0-14/21	Sb	Pale brown 10 YR 8/3
	II	AB	14/21-42/44	Sb	Yellow 10 YR 7/6
Forest 2	I	A	0-11/17	Sb	Light brown yellowish 10 YR 6/4
	II	B1	11/17-42/45	Sb	Brownish yellow 10 YR 6/6
	III	B2	42/45-73/80	Sb	Yellow 10 YR 7/8
	IV	B3	73/80-95/115	Sb	Dark brown 7,5 YR 5/8
Grassland	I	A	0-8/12	Ab	brownish yellow 10 YR 6/6
	II	AB	8/12-37/52	Sb	Yellowish red 7,5 YR 7/8
	III	B1	37/52-73/75	Sb	Yellowish red 7,5 YR 7/8
	IV	B2	73/75-87/102	Sb	Yellowish red 5 YR 7/8
Bottom Slope Position(LSP)					
Grassland 1	I	A	0-13/19	Sb	Light yellowish brown 10 YR 6/4
	II	B1	13/19-34/36	Sb	Brownish yellow 10 YR 4/6
	III	B2	34/36-60/66	Sb	Dark brown 7,5 YR 5/6
	IV	B3	60/66-92/97	Ab	Dark yellowish brown 10 YR 6/4
Grassland 2	I	A	0-14/16	Sb	Light gray chocolate 10 YR 6/2
	II	B1	14/16-39/44	Sb	Very brown 10 YR 7/3
	III	B2	39/44-81/87	Sb	Yellow 10 YR 7/6
	IV	B3	81/87-95/105	Ab	Reddish yellow 5 YR 5/6
Forest 2	I	A	0-15/22	Sb	Brownish yellow 10 YR 6/6
	II	AB	15/22-38/44	Sb	Pale brown 10 YR 7/4
	III	BC	38/44-49/58	Ab	Brownish yellow 10 YR 5/8

Notes: sb (rounded cube), ab (angular cube)

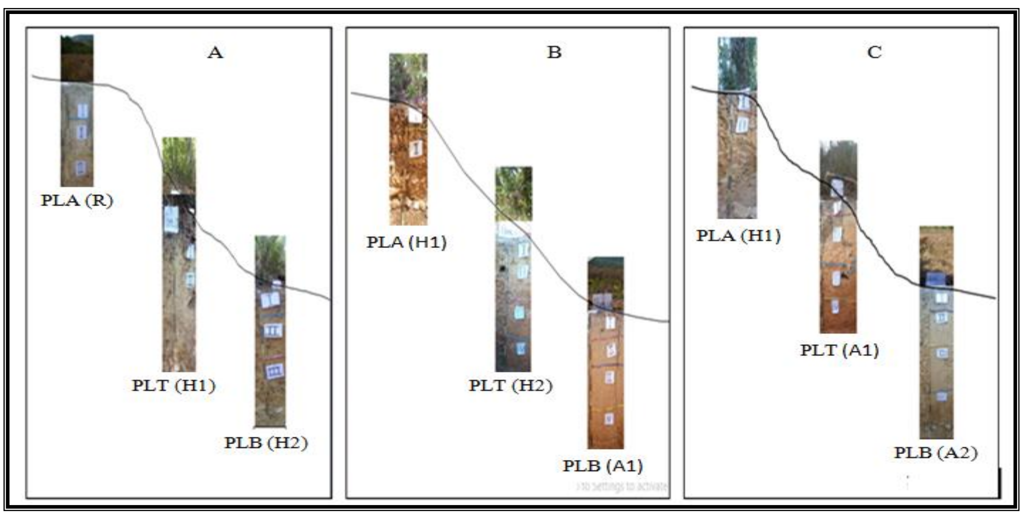

Figure 1;Sectional profile of soil on slope position differs in research location, A (Sample I):
PLA I upper slope position with grass vegetation; PLT (H1) middle slope position with vegetation of forest 1; PLB (H2)bottom slope position with vegetation of forest 2. B (Sample II): PLA (H1) upper slope position with vegetation of forest 1, PLT (H2)position middle slope with vegetation of forest 2; PLB (A1) bottom slope position with vegetation of grassland 1.C (Sample III): PLA (H1) upper slope position with vegetation of forest 1; PLT (A1) middle slope position with vegetation of grassland 1; PLB (A2) bottom slope position with vegetation of grassland 2.

The condition is closely related to the level of soil development indicated by the difference in the solum in each profile as the effect of different weathering and stocking intensities. Especially in PLB have solum which average belong to deep because PLB have sedimentation due to erosion or surface flow that bring mass of land from PLA and PLB. Different soil colors, especially in top soil layer (layer I) and top soil (layer II) are closely related to different organic material content due to the influence of vegetation type when the growth parts are physiologically dead and weathered. The visualization of the profile with the appearance of several differences in morphological properties including top soil colors that appear different and suspected as contributions of organic matter from different weathering vegetation types (Figure 1).

The results showed that there were differences in the appearance of morphological properties at different slope positions at the study sites, the number of layers and the horizon, the depth of solum and the thickness of the layers, especially in the lower slope position (PLB) showed the average depth of solum. The fact is that the slope of the bottom (PLB) is accumulating due to erosion or surface flow that carries the soil mass from the upper slopes (PLA). The vertical movement of the water will dissolve the soil materials which cause the materials to decrease and accumulate in the lower slopes (PLB). The slope position also influences the size of the surface flow, where the water flowing in the ground will accumulate at the bottom of the slope, so that the more water that flows the greater the speed of land accumulation at the bottom of the slope.

The soil is destroyed by the collision of rainwater, and it will be transported by the flow of the surface, so that on the bottom slope occur the input of soil material derived from the upper slopes, the destruction of the soil, and transport. On the other hand, there is an output (erosion) on the upper slopes due to transport. This fact indicates that the soil profiles at the upper slope position (PLA) does not yet have advanced weathering levels and includes newly developed lands. The opinion is relevant with statement (Darmawijaya, 2007); Lawal et al. 2014), that the development of the soil can be seen based on the morphological, physical, chemical and mineralogical properties of the soil by comparing the horizontal properties of one profile vertically and horizontally between profiles. Rajamudin (2009) stated that the depth of the soil solum is highly dependent on the circumstances in which the soil is formed as a result of the interplay between the factors and the process of formation of the land concerned.

The soil color in each slope position differs particularly in the topsoil layer which is suspected as the effect of the existence of different vegetation especially in relation to the contribution of organic matter due to humus from weathering the parts of the vegetation which physiologically die and decay into humus organic matter. The results of the study in Table 2 show that on the top slope position (PLA) with grass vegetation, the topsoil layer is light gray, vegetation forest1 (*songi tree, eha tree*) is very brown, forest vegetation 2 (*ruruhi tree, rattan, pandanus*) is yellow. The topsoil color on center slope position (PLT), for forest vegetation1(*songi tree,eha tree*) is pale brown, forest vegetation 2 (*ruruhi tree, rattan, pandanus*) is light yellowish brown, for brownish brownish-brown vegetation. While in the down slope position (PLB) topsoil soil layer color for grassland1 is light yellowish brown, grassland 2 is brown light gray, and forest is yellowish brown.

These facts from this result of research indicated that at different slope positions have different organic materials and mineral compositions. This opinion was reinforced by the Mulyanto et al. (2006) that soil color is one of the most important parameters in interpreting soil properties, such as the content of iron and manganese oxides and hydroxides. It is relevant with Notohadiprawiro (2000) the soil colors other than influenced by by oxide, hydroxide, iron and manganese compounds were also affected by the accumulated organic material and the mineral composition. The land that has undergone further development is lighter than the newly developed soil tends to be darker.

The Soil Chemical Properties

The characteristics of soil chemical properties on different slope positions showed in Table 2.

The soil pH (pH H2O) in general can be categorized into two ie: sour (4.5-5.5) and rather sour (5.6-6.5). The highest average of pH on PLB (5.40), PLT (5.20) and lowest is PLA (5.0).

The highest average of CEC is PLT (32.47 me 100g-1), PLA (28.39 me 100g-1) and lowest is PLB (20.67 me 100g-1). The highest of organic matter content is PLA (2.44%), PB (1.61%) and lowest is PLT (0.89%).The relationship between pH, CEC,and organic matter at the each slope position is presented in Figure 2.

Table 2;Characteristics of soil chemical properties on different slope positions in North Moramo District of South Konawe Regency

Vegetation Type	Soil Layer	Characteristics of Soil ChemicalProperties			
		pH H_2O	pH KCl	CEC (me $100g^{-1}$)	Organic Matter (%)
----------------------------- Upper Slope Position (PLA) -----------------------------					
Forest 1	I	4.50	3.62	26.57	6.00
	II	4.79	3.62	28.73	1.29
Sub Average:		4.65	3.62	27.65	3.65
Forest 2	I	5.61	4.07	36.57	3.61
	II	5.44	4.12	25.29	2.00
Sub Average:		5.53	4.10	30.93	2.81
Grass	I	4.91	3.82	25.13	2.86
	II	4.84	3.84	25.11	0.88
	III	4.92	3.84	31.36	0.43
Sub Average:		4.89	3.83	27.20	1.39
Average		5.00	3.85	28.39	2.44
----------------------------- Middle Slope Position (PLT) -----------------------------					
Forest 1	I	4.88	3.78	22.05	0.84
	II	4.79	3.88	20.53	0.47
Sub Average:		4.84	3.83	21.29	0.66
Forest 2	I	5.94	4.15	36.42	2.79
	II	5.49	4.10	36.75	0.73
	III	5.06	3.87	47.35	0.55
	IV	5.03	3.84	25.08	0.45
Sub Average:		5.38	3.99	36.40	1.13
Grassland	I	5.32	4.01	41.90	1.11
	II	5.45	4.05	40.30	1.11
	III	4.94	3.84	20.25	0.49
	IV	5.07	3.83	33.97	0.35
Sub Average:		5.20	3.93	34.11	0.77
Average		5.20	3.94	32.46	0.89
----------------------------- Bottom Slope Position (PLB) -----------------------------					
Grassland 1	I	5.10	3.87	13.31	2.28
	II	5.12	3.75	23.87	0.91
	III	5.32	3.88	19.64	0.45
	IV	5.41	4.02	14.19	0.07
Sub Average:		5.24	3.88	17.75	0.93
Grassland 2	I	5.60	4.16	24.02	4.92
	II	5.80	4.19	24.89	1.80
	III	5.22	3.89	17.75	0.87
	IV	5.13	3.94	23.61	0.73
Sub Average:		5.44	4.05	22.57	2.08
Forest 2	I	5.58	4.15	24.84	3.05
	II	5.79	4.21	23.90	1.49
	III	5.32	3.89	17.36	1.18
Sub Average:		5.56	4.08	22.03	1.91
Average:		5.40	4.00	20.67	1.61

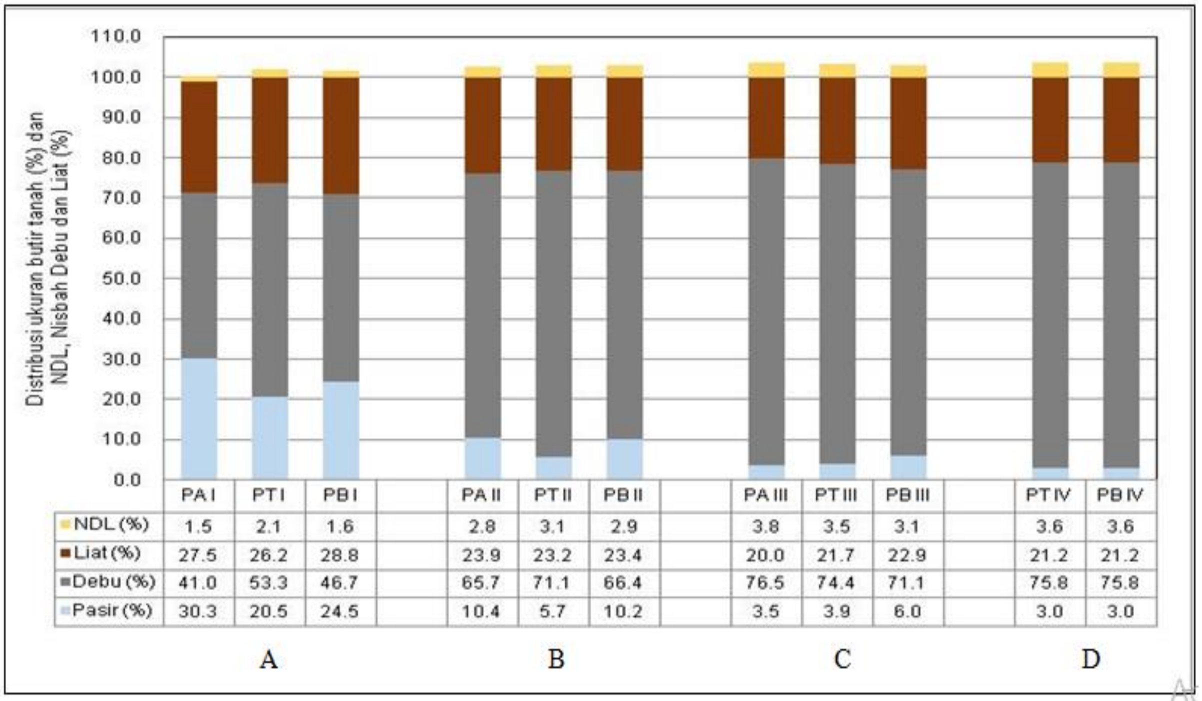

Figure 2; Distribution of sand fraction, dust and clay with ratio of dust and clay

A. Soil layer I, upper slope position, middle and lower (PA I, PT II, PB III)
B. Soil layer II, upper slope positions, middle and lower (PA II, PT II, PB II)
C. Soil layer III, upper slope position, middle and lower (PA III, PT III, PB III)
D. Soil layer IV, middle and lower slope position (PT, IV, PB IV)

The results showed that pH values on the three slope positions at the research sites were generally low (sour), presumably that the soils were derived from the same parent material and strongly influenced by sediments that were decaying and continuing especially at different slope positions. The fact was relevant to the statement Hardjowigeno (2003), that the further weathering of a soil will react very sourly along with the rate of development of the soil. It further arguedthat soil pH may be affected by the decomposition of organic matter, parent material, precipitation, natural vegetation, depth of land, and topography. This is reinforced by opinion Alam et al. (2011), that the role of topography (slope) 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 position of the upper slopes, the central slopes to the lower slopes. In addition to the pH value, the cation exchange capacity (CEC) of the soil at the study site also has arelatively low value (5-16.99 me 100 g-1) to the very high category (>40 me 100 g-1) and differs on third position ofthe slopes studied. The highest CEC value of the soil is found in the middle slope position profile (PLT) with forest vegetation2 (47.35 me 100g-1) and the lowest is in the bottom slope (PLB) profile profile with grassland vegetation (13.31 me 100g-1). This fact indicates that the soil at the study site is classified as the rate of development of newly developed and developing soils.

The result of research (Figure 3), it is appears that in general the three slope positions have a sour pH except in layer I having a somewhat acidic pH. The highest CEC in the PLT varies in each soil layer, the lowest in the PLB and varies in each soil layer. The content of organic matter also varies, the highest in the PLA and the lowest in the PLB, but shows the same model on the three slope position that the organic matter content decreases with the deeper the layer of soil.

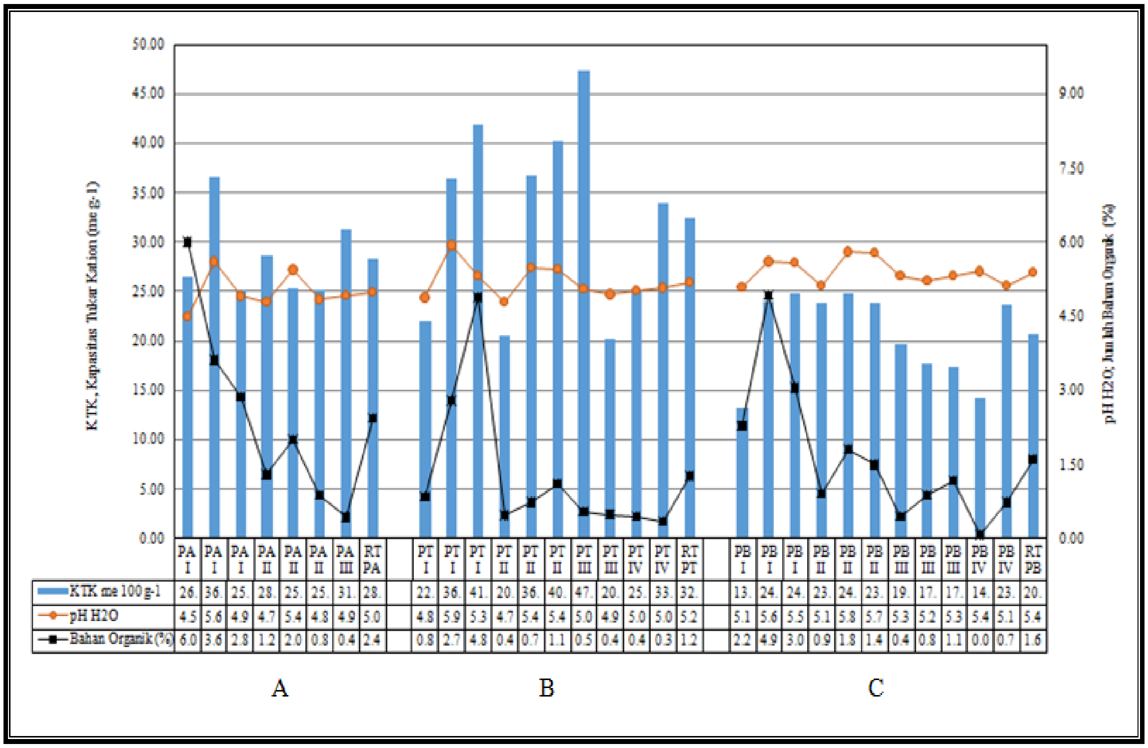

Figure 3;Distribution of pH value, CEC and organic matter:

A. Upper slope position, soil layer I, II, dan III (PA I, II, III)
B. Middle slope position, soil layer I, II, III, and IV (PT I, II, III, IV)
C. Bottom slope position, soil layer I, II, III, and IV (PB I, II, III, and IV)

This is closely related to the effect of weathering of organic matter occurring in layers I and II that do not have a deeper coating.

The young soil is a new land undergoing the process of soil formation especially the weathering process of organic matter, while the adult soils undergo further process both in the process of soil formation and the process of weathering organic materials so that at this stage the land is able to provide more nutrients as a result of mineral weathering and organic matter (Hardjowigeno, 2003; Putra et al., 2014). They were reported that the role of organic matter in the soil is to increase the availability of nutrients from the decomposition, stabilize the soil aggregate as a buffer of soil changes, increasing soil CEC as well as a source of energy for the activity of certain soil microorganisms. The soils that have high CEC grades are able to absorb and provide better nutrients than those with low CEC or sandy soils (Rajamuddin, 2009).

The size of soil CEC value is influenced by soil reaction, texture or the amount of clay, clay mineral and organic matter (Six et al. 2005). Soils with high organic content or high clay content have a higher CEC value than those with low organics matter or sandy soils. Levels of soil organic matter at three slope positions observed are generally classified as very low to very high. Especially in topsoil layer (layer I) indicates high criterion (>2-4%), including profile on upper slope position (PLA) with grass vegetation, forest vegetation 2, center slope position with forest vegetation 2 in layer I, down (PLB) with grassland1 vegetation, forest vegetation, and very high criteria (>4-6%) in the upper slope position profile (PLA) with forest vegetation1 in layer I, middle slope position with grassland vegetation in layer I, bottom slope position (PLB) with grassland 2 in layer I.

Alternative Conservation Method

The result of overlay between climatic and soil characteristics indicates that appropriate conservation techniques in the research sites, especially in the middle slope position are structured vegetative techniques; including PH = live fence, ST = Strip of grass or natural plant strip, PT = Cover plant, and BD = Aquaculture hallway. Similarly, on top and bottom slope positions with appropriate vegetative conservation techniques, including cover crops and live fences. The directive is relevant to the opinion (Wahyuningrum and Supangat, 2016), that to minimize the occurrence of high erosion, soil and water conservation both civil and vegetative. Furthermore, it was proposed that vegetative conservation methods were able to reduce erosion by about 40.672%. Jafari et al. (2014) the using of land should pay attention to the characteristics of the land because if it is not appropriate will cause ecological problems can even lead to the deterioration of natural resources within the area to refer. According Taghvaye et al. (2008) the degradation and loss of land productivity are two environmental problems that can occur, especially in relation to land use

Therefore, in an effort to achieve sustainable agriculture and forestry development and improve environmental improvements, land use should be based on permissible exploitation (Najibzadeh et al., 2008). It is also in accordance with the statement (Baja, 2012; Hamdami et al., 2013), that land use planning is an attempt to locate areas suitable for application development based on ecological characteristics. The slope position and land use of cover is a key factor affecting soil properties under hillside and micro-scale areas (Bronson et al., 2008; Wang et al., 2013). Land use change or cover is related to micro-climate change (Ezber et al., 2007). Therefore, land use and vegetation type should be seriously taken into account when dealing with nutrient status with environmental conditions (Yang et al., 2013), can be an indicator of land quality estimates (Poeplau et al., 2011). Differences of slopes also cause differences in the amount of water available for plants that affect the growth of vegetation in the place (Hardjowigeno, 2003; Akbaril et al., 2014).

In general, the results of the study indicate that the difference in slope position results in different soil characteristics although it develops in the same parent and climatic material. The characteristics of soil formed at the location of the study ranging from the upper slopes to the bottom slope include soil morphological characteristics inthis case the depth of solum, solum thickness and the appearance of horizons that have not been formed perfectly, soil physics characteristics such as texture and structure are almost uniform and not fluctuate and high values of dust and clay ratio, chemical characteristics such as pH, CEC and lower tending organic matter (Yuswandi et al., 2015).

The improper land use patterns and not based on the assessment of soil characteristics with soil and water conservation rules can lead to loss of cover vegetation (Kosmas et al., 2000; Sahetapy, 2009). This opinion is relevant to the statement Hardjowigeno (2003); Pratiwi and Narendra, (2012); Kartiwa and Dariah (2013) that the assessment of land characteristics and proper application of soil and water conservation systems depends on the characteristics and quality of the land such as slope, soil effective depth, available pore water, soil texture, soil structure, soil drainage, surface rocks, soil acidity and soil fertility. Similarly statement Rayes (2006); Baja, (2012) differences in land characteristics and qualities lead to differences in land suitability for land use, especially land use for agriculture and forestry. According Hidayat and Mulyanai (2005);Kandari et al., (2013); Kandari et al., (2014); Mulyani (2003); Kandari et al., (2014) that each type of food crop can be cultivated on suboptimal land but must be supported by appropriate management, including adjustment of cultivation techniques, land suitability assessment and site determination, selection of plant species and timing of proper planting. Similarly with statement Kandari et al., (2015), for forestry crop development can be done on suboptimal land through the determination of the exact location, especially the suitability of soil and climate and the selection of superior types of forestry crops.

CONCLUSION

Based on the results of research and discussionthat has been described, concluded as follows: (1) the pH value of the three slope positions in the study location was generally classified as low (sour) (2) the highest soil CEC value is found in the profile of the middle slope (PLT) with forest vegetation 2 (47.35 me $100g^{-1}$) and the lowest is in the profile of the lower slope (PLB) with grasses (13.31 me 100g-1), (3) conservation techniques according to the location of the research especially at the position of the middle slope i.e.; structured vegetative technique (PH = living fence, ST = grass strip or natural plant strip, PT = cover crop, and BD = aisle cultivation).

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. Halim were wrote the manuscript. All authors read and approved the final version.

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