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DAFTAR ISI

LAND CAPABILITY OF LABANAN SOIL TO RAINFED, PERENIALS AND FOREST PLANTATIONS

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ABSTRACT

A Semi detailed land suitability classification have been reseached about 2508.59 Ha at Labanan Village, Berau Regency of East Kalimantan Province. The survey area by climatic data studied has an optimum climatic characteristic to required Oil palm cropping such as rainfall, temperature and solar radiation.

From 75 observation points on soil morphology, have been selected 12 profiles for detail study included chemical analyzed. The soils in this area classified into five taxonomic Subgroup level, and dropped into eight family level. Soil fertility and morphology are recognized to identification of soil mapping units to land suitability classification for palm plantation. The study showed that the most limiting factors are low to very low cation exchange capacity, Base saturation and sum of basic cation. Alumunium saturation, although it may very widely, should not used as a criterion for distinction to growth factors of Oil palm evaluation because it can easily be amended and tolerance of oil palm to aluminium varies strongly.

The suitability classification of soil mapping units of the studied area according to land characteristics (Climate, Soils and Landscape) of surveyed area, compare to land characteristics of Rainfed (Maize) and Perennial (Oil palm) were Marginally Sitable (S3tf) on soil mapping units 2 by topography, base saturation, sum of basic cation and pH limiting factors. Actually unsuitable (N1tf) on soil mapping units 1 and 5 topograpy, sum of basic cation and pH limiting factors. Actually unsuitable (N1tfs) on soil mapping units 3 by topography, texture, sum of basic cation and pH limiting factors. Actually unsuitable (Nitfs) on soil mapping units 4 by topography, soil depth, base sarturation, sum of basic cation and pH soil limiting factors. The high range of topographic classes were dominantly limiting factor as well fertility and physical soil characteristic. To developed oil palm plantation on the certain area, advisable to use the Nucleus Estate System (NES), low level management for rainfed and mostly suitable for forest plantation. To minimized erosion hazard cause of land clearing, cropping terrace and applied of legume cover crops is recommended. To have high yield and its sustainability maintain of litter and humus content in the soil rather than burning should propagate during land clearing activity. Soil acidity and phosphorous fixation can be improve by liming.

Key words : soil morphology, soil characteristics, soil fertility

INTRODUCTION

The East Kalimantan Province has an area of about 21 million hectares, most of them covered by an evergreen rain forest mainly composed by Dipterocarp. Sp. The population density is low and provides the possibility for farming and plantation development. Nowadays, the main priorities of the plantation sectors are the rubber, coconut, cacao, and oil palm.

All form of farming and plantation or other uses of the land depend on the soil and its landscape, Soil Taxonomy is a soil classification system providing a common language for communicating about soils, and land evaluation is the assessment of land performance when used for specified purpose. At present, most

system of land evaluation is interpretative classification. They present an evaluation in different categories, each corresponding to a certain level of detail. At each level, the interpretation differs in procession, objective, requirement and assumption.

Generally, in the utilization of the land for oil palm plantation in East Kalimantan have been applied both, soil classification i.e. Soil Taxonomy, FAO-Unesco, Center for Soil Research (CSR) systems and land evaluation system (FAO-Unesco) for identification and determination of land capability.

The research should permit to find out to what extend both Soil Taxonomic system and Land Suitability Classification can be apply to Labanan soils for determination of Oil palm plantations.

The land Suitability Classification done based on the Soil Mapping Units. The soil Mapping Units its self distinguished on the soil which have similar taxa (Family level), soil depth, physiography/landform, and parent materials. By this research we hope to able the provide objective information to development Maize and Oil palm plantation in the Labanan area, Berau Regency of East Kalimantan.

APROACH AND METHODOLOGY

The semi detailed soil survey for the Maize, Oil palm and forest plantation at Labanan Village have been done on the selected area about 2000 hectares at the scale 1 : 25.000 particularly at Labanan forest, Berau Regency is conducted at the following phase : Preparation phase, Field operation phase, Laboratory analysis and data handling.

At the preparation phase, activities conducted to simplified of field survey area as follow : a) Study of literature and data information of the area being surveyed Base map preparation as the network to make traverses plan, observation location, and field operation ; b) Prepare materials and equipment for field operation.

Field Operation phase

Field operation done using semi detailed soil survey methods including activities : a) The reinforcement of distinction survey areas in topography classes, landform/slopes using land systems ; b) The observation of the soil morphological characteristic systematically through mini pit and soil profiles.

Soil observation done through mini pits and soil profiles pits. Mini pits of about 40 to 50 cm deep, while deeper layers studied by auger borings to a depth of 150 cm or to bedrock. Profiles pit dug to a depth of 150 cm, while deeper layers studied to bedrock by auger or to 200 cm depth. Soil sample of about 1 kg taken from all soil horizons in every layer of the pits.

The soil profile description was based on "guidelines for soil profile description" (FAO,1990). Using 100 ml soil sampling cores collected the undisturbed soil samples for physical analysis (Bulk Density).

Laboratory analysis

The analysis of soil characteristics of the sample both chemically and physically was done in soil laboratory of Mulawarman University. Laboratory result analysis is needed to reinforce and support the

filling up of land suitability map in developing oil palm plantation. The soil sample analyses composed of routine analyzes as : Particle size distribution, Bulk Density (g/cc), pH (H_2O, KCl), CEC (Cation Excharge Capacity), meq/100 gr soil, ECEC (Effective CEC), meq/100 gr soil, Base Saturation (%), Exchangeable bases (Ca, Mg, K, Na), meq/100 gr soil, Al (Exchangeable Al) meq/100 gr soil, H (Exchangeable) meq/100 gr soil, Organic Carbon (%), Total Nitrogen (%), Phosphorous both total or available (ppm), Potassium both total and available (ppm).

Data analysis and handling

Base on the information recorded in soil profiles description, each pedon is check for all requirement of the keys to Soil Taxonomy for order, subgroup, Greatgroup, Subgroup and Family. The land suitability classification for Maize and Oil palm plantation of survey area evaluated on the Soil Mapping Units.

Soil Moisture Regimes (SMR) and Soil Temperature Regimes (STR) have been computed for the whole East Kalimantan on the basic of the available climatological data, using Franklin Newhall Simulation System.

The land suitability classification of the surveyed area assessed for Maize and Oil palm plantation. The system of land suitability classification used is that of the FAO (1976) which Sys and Van Ranst (1993) have modified.

RESULT

Location and communication

The Labanan area is located to the South-West capital district of Berau (Tanjung Redeb). The survey area geographically is situated between 2° 00' 31" to 2° 02" 31" North Latitude and between 117° 14' 10" to 117° 19' 09" East Latitude. The Eastern boundary of the survey area is closely located to Tumbit Dayak Village.

Hydrology

The survey area belongs to the Tumbit catchment area. Tumbits river itself flows from West to East, ending to the Kelai river. The Tumbit river has about 15 km length by catchment area of more than 10 km^2 .

Tumbit Dayak village situated at the river basin of Tumbit river has flood potentially mainly during rainy season and can overflow almost all of the area, especially at Bakunan (BKN) land system, which commonly found at the riverbanks with the flooding period of more than a day.

Climate

General climate ; The climate of the region and the survey area is of the Af-Tropical rain forest climate in Koppen's system, i.e. a tropical rain forest climate without dry month and temperature of more than 22° C during the warmest month.

Rainfall ; The rainfall is spread over the whole year, but there is evidence of periodic dry spells, especially periodically of every 15 years (1982/1983-1997/1998). This periodic dry spell probably associated with the " El Nino" events where forest fires were observed in the Labanan area. The average annual rainfall ranges from 1501,4 (1992) to 2685,8 mm (1996). The days rain ranges from 12.6 days on June to 21.4 days on January.

Temperature ; The temperature fluctuations are very small. The difference between mean annual summer temperature and mean annual winter temperature is less than 2° C. All months have a mean temperature greater than 26° C.

Other climatic data

The average monthly relative humidity values range from 80.4 to 84.7 %. The highest value occurs in January and the lowest in July. The mean sun radiation (g cal/cm2 /day) has the highest value in April (545.5 g cal/cm2/ day) and the lowest in January (292 g cal/cm2 /day) (data collected from Muara Marah station in 1980-1985). The potential evapotranspiration has been calculated according to the Papadaki's methods. The potential evapotranspiration of the area is around 2.71 to 3.64 mm/day or 1097 mm/year.

Soil climatic regime

Soil moisture regime (SMR) and soil temperature regime (STR) have been computed for the whole of East Kalimantan on the basis of the available climatological data and using Franklin Newhall System of computation.

Geology

Geology of part of East Kalimantan is described by Van Bemmelen (1949) with maps at 1:1 million scale, based in part on the earlier 1 : 250.000 scale map of Ubaghs et al. (1932).

From these two sources a sketch map (figure 3) about the geology of the study area has been prepared. The geology of the survey area is dominated by late tertiary sedimentary rock, in strata mainly trending South West to North East. The rocks are weakly lithified and show considerable short range variation in texture, ranging from sandstone to mudstone and claystone. Conglomerate strata were seen in several rock- side exposure and river.

Sedimentary rocks and the coarser alluvial deposits contain few or very few weatherable minerals and so the soils formed from these materials have low to negligible contents of most plant nutrients.

Topography

The surveyed area can be devided into two main topographic classes. Firstly, the basin of small tributaries of Tumbit river. This area almost flat, less than 8% slope and form a depression. Secondly, the remaining area, which consists of rolling to dissected ridges and low hills which in many places rise abruptly from the river basin. This relief is made up as the result of the considerable folding activity during geological times. Slope

greater than 15 % is predominate, they are generally 150 meters or less in length and the amplitude is typically in the range of 25-50 m.

Soil Morphology and Classification

The morphology of most Ultisols is dominated by horizon of eluviation and illuviation. Soil Taxonomy and other literature indicate that soils classifying as Typic Hapludults are the central concept of the Ultisols order. An Ochric epipedon overlying Yellow, Brownish Yellow, Reddish Yellow Argillic horizon is thus near model of surveyed area. A Typical horizon sequence is A, AB, Bt, BC, C. Common texture are sandy loam in A, AB and sandy clay, clay loam and clay in the argillic horizon. Clay content increase regularly from A, AB or upper B horizon to a maximum in the middle part of the argillic horizon, than decrease regularly with depth to the C horizon. Thickness of solum were grouped into 50-100 cm, 100-150 cm and > 150 cm depth.

In consideration of distinguished soil morphology and classification, from 75 observation points, were selected eleven (11) soil profiles. Most of the soil profile study has Ochric epipedon and one an Aquic Soil Moisture Regime. In general, soil has Argillic or Kandic subsurface horizon, except profile number 55b which considered into Cambic subsurface horizon.

Clay mineralogy on soil control section

Clay mineralogy for soil Family level also studied in order to identification clay mineralogy in control section. CEC of clay with correction of CEC soil reduced CEC organic was approached. Those soils has CEC clay more than 10 meq/100 gram described as mixed layers and those has low than 10 meq/100 gram as Kaolinite.

Soil Mapping Unit (SMU)

Soil mapping unit consist of low level taxonomic units (Series). When it become impossible to characterize mapping units in term of single taxonomic units, a regrouping is required, they are : association and complex.

Five soil mapping units of the surveyed area have been differentiated base on Soil Seri. Each soil mapping units has explanation about important soil characteristics included particle size distribution (texture of top soils), drained, effective soil depth, soil reaction (pH), CEC, base saturation and others soil morphological characteristics.

Soil Mapping Unit 1.

Soil mapping unit 1 composed of Fine, Kaolinitic, Isohyperthermic, Typic Kandiudults (Haplic Acrisols/Podsolik Kandik), well drained, deep of effective soil depth and ground water table (> 150 cm), organic layers 2-4 cm thick with the Ah horizon between 4-8 cm depth, and horizon sequence O, Ah, AB, Btl, Bt2, Bt3, Bt4, BC and C, pale brown to dark brown (10 YR 6/3-4/3) topsoils color, sandy loam to loam,

crumb to sub angular blocky structure, friable consistency, upper and lower argillic horizon range between 13 to 180 cm depth from the soil surface.

This soil mapping units situated at the peneaplain area (Hog-bag), formed by sandstone with seam of conglomerate layers, hilly physiography, slope range 41-60 %, slope length 40-60 m, and relative difference in elevation 25-50 m.

Soil mapping unit 2.

Soil mapping unit 2 composed of Fine, mixed, Isohyperthermic, Typic Kandiudults and Fine silty, mixed, Isohyperthermic Typic Kandiudults soil association (Haplic Acrisols/ Podsolik Kandik), well drained, deep of effective soil depth and ground water :able (> 150 cm), Ah horizon between 4-7 cm depth, and horizon sequence Ah, AB, Btl, 3t2, Bt3, BC and C, Light yellowish brown, brownish yellow to dark brown (10 YR 6/4- 6 6-4/3) topsoils color, sandy loam to clay loam, sub angular blocky structure, friable consistency, upper and lower argillic horizon range between 19 to 150 cm depth from the soil surface.

This soil mapping units situated at the peneaplain area (Cuesta), formed by sandstone, rolling to hilly physiography, slope range 16-25 %, slope length 20-70 m, and relative difference in elevation 15-30 m.

Soil mapping unit 3.

Soil mapping unit 3 composed of Fine silty, mixed, Isohyperthermic, Grossarenic Hapludults (Haplic Acrisols/Podsolik Haplik), well drained, deep of effective soil depth and ground water table (> 150 cm), Ah horizons between 2-5 cm depth, and horizon sequence Ah, AB, B, Btl, Bt2, Bt3, BC and C, pale brown to brown (10 YR 7/4-5/3) lopsoils color, sandy loam, sub angular blocky structure, friable consistency, upper and lower argillic horizon range between 28 to 101 cm depth. This soil mapping units situated at the peneaplain area (Cuesta), formed by sandstone, rolling to hilly physiography, slope range 26-40 %, slope length 40-60 m, and relative difference in elevation 15-40 m.

Soil Mapping unit 4.

Soil mapping unit 4 composed of Fine, mixed, Isohyperthermic, Typic Hapludults (Haplic Acrisols/Podsolik Kandik) by inclusion Coarse loamy, mixed, non-calcareous, Isohyperthermic, Aeric Tropaquepts (haplic Gleysols/Kambisols Gleiik), well drained, moderate effective soil depth (50-100 cm and deep ground water table (> 150 cm), organic layers 1-2 cm thick with the ah horizon between 4-12 cm depth, and horizon sequence O, Ah, AB, Btl, Bt2C, and C/R dark grayish brown to dark brown (10 YR 4/2- 7.5 YR 4/2) topsoils color, crumb to sub angular blocky structure, friable consistency, upper and lower argillic horizon range between 9 to 65 cm depth.

This soil mapping units situated at the peneaplain area (Hog-bag), formed by sandstone with seam of conglomerate layaers near the surface, hilly physiography, slope range 41-60%, slope length 40-60 m, and relative difference in elevation 25-50 m.

Soil Mapping Unit 5.

Soil mapping unit 5 composed of Fine, mixed, Isohyperthermic, Typic Kandiudults and Fine silty, mixed, Isohyperthermic, Typic Hapludults (Haplic Acrisols / Podsolik Kandik and Podsolik Hapik(), well drained, deep of effective soil depth and ground water table (> 150 cm), the Ah horizon between 3-8 cm depth, and horizon sequence O, A, AB, Btl, Bt2, Bt3, Bt4, BC and C, yellowish brown to brown (10 YR 5/6-5/3) topsoils color, sandy loam to loam, crumb to sub angular blocky structure, friable consistency, upper and lower argillic horizon range between 17 to 128 cm depth.

This soil mapping units situated at the peneaplain area (Hog-bag), formed by sandstone with seam of conglomerate layers, hilly physiography, slope range 41 – 60 %, slope length 40-60 m, and relative difference in elevation 25-50 m.

Evaluation of Land Suitability Classification of Survey area

Based on land characteristics (climate, soil and landscape) of the surveyed area, the degree of land suitability classification for Maize and Oil palm plantation of each soil mapping units as a specific land utilization types have been determined. The main limiting factors of the area are topography classes, soil fertility (pH, Base Saturation, Sum of basic cation, pH) and soil physic such as texture (SMU3) and effective soil depth (SMU 4). Relative humidity on maturation stage of Maize growing cycles had the majority of degree limitation to rainfed plantation intensively.

CONCLUSIONS AND RECOMMENDATIONS

The surveyed area of Oil palm plantation by PT. Inhutani I/BFMP at Labanan, Berau, East Kalimantan has an optimum climatic characteristics to require Oil palm cropping such as rainfall, temperature and solar radiation.

From soil morphological, chemical and other criteria, the soils in this area are classified into five Taxonomic Subgroup level, were dropped into eight different Family level i.e. Coarse loamy, mixed, non-calcareous, Isohyperthermic, Aerie Tropaquepts; Fine silty, mixed, Isohyperthermic, Groassarenic Hapludults; Fine silty, mixed, Isohyperthermic, Typic Hapludults; Fine, mixed, Isohyperthermic, Typic Hapludults; Fine, mixed, Isohyperthermic,

Typic Kandidults; Fine silty, mixed, Isohyperthermic, Typic Kandiudults; Fine, mixed, Isohyperthermic, Typic Kandiudults, and Fine, Kaolinitic, Isohyperthermic, Typic Kandiudults.

Soil fertility evaluation and land suitability classification to Maize and Oil palm plantation showed that, the most limiting factors of the surveyed area are low to very low action exchange capacity, base saturation and sum of basic cation. The terrain is the main limiting factors of the whole area with slope steeper than 15 % in general, although relative humidity on maturation stage to rainfed plantation due to reduce harvest of maize.

Nutrient status of the whole soil mapping units is extremely low. The total Nitrogen is generally low to very low i.e. range between 544 kg/ha to 840 kg/ha or correspond to 21.76 to 33.6 kg/ha available

Nitrogen. Available Phosphorous, however, is generally less than 10 % of this amount compare than its total, and content in the subsoils are lower still. Sometimes, there is marked accumulation of nutrients in the topsoils of profiles, but this reserve is low and is easily exhausted upon cultivation.

Potassium content varies from low to high status. The initial rise in potassium content is explained by sudden liberation of this element upon burning of forest vegetation and litter. The high of potassium content in the surveyed area probably caused of potassium liberated from decomposition of organic matter and parent materials.

The still higher organic matter content of the soil prevents the leaching of elements to some extent and has a buffering effect on the contents of total and available nutrient in the surface soils.

Experienced show that available phosphorous and potassium are relatively uneffective by several years of cultivation caused by lack of other elements.

Based on the soil fertility evaluation and land suitability classification to Maize and Oil palm plantation showed that, the most limiting factors of the studied area are slope and climate as well and other characteristics such as low to very low cation exchange capacity, base saturation and sum of basic cations, especially the important cation such as calcium and magnesium.

The others limiting factor to development is terrain of soil mapping unit i.e. have rolling to hilly topography with slope steeper than 15 %. The relative difference in elevation higher than 25 m and generally the length in slope less than 150 m. The Hogback landform much steeper than cuesta because in the hog-back landform both slopes are steep.

The area of soil mapping units 2 is the best for developing Maize and Oil palm plantation compared to others soil mapping units. This mapping unit having topography relatively lower with the range of sloping from 16-25 %. The main problem of this mapping unit is relating to soil acidity (pH), base saturation, sum of basic cation and of course phosphorous retention capacity.

REFERENCES

Ansyahari., R.P. Bower., R. Hoffman., M. Nitsch and D.R. Speller. 1984. Land Capability Classification Muara Muntai and Tanjung Isuy. Technical Coopertaion for Area Development Kutai District, East Kalimantan. 66 p.

Boul, SW., F.D. Hole and R.J. McCraken, 1980. Soil Genesis and Classification. The Iowa State University Press, Ames. 406 p.

CSR, 1983. Term of Reference. Jenis dan Macan Tanah di Indonesia Untuk Keperluan Survai dan Pemetaan Tanah Daerah Transmigrasi. Pusat Penelitian Tanah No. 59a/1983, Bogor. 25 p.

CSR, 1983. Survai Kapabilitas Tanah. Pusat Penelitian Tanah P3MT No. 59b/1983, Bogor, 52 p.

Desaunettes, J.R, 1977. Catalogue of Landforms for Indonesia. Fao-Soil Research Institute, Bogor. 111 p.

FAO, 1988. FAO-Unesco Soil Map of the World. Revised Legend. World soil Resou- ces Report. Rome. 60 p.

FAO, 1990. Guidelines for Soil Description. 3rd ed (rev).)., FAO/ISRIC, Rome.

Mantel. S, 1997. Soils and Terrain of the Labanan Area. Development of Environmental Framework for the Berau Forest Management Project.48 p.

Mulyadi, 1989. Classification of Soils From East Kalimantan Selected for the Transmigration Area development Project According to the USD A (1975 and 1987) and FAO Classification System (1974). Thesis of the State University of Ghent, Belgium. 96 p.

Mulyadi, 1992. Regime Kelembaban dan Suhu Tanah Menurut Sistem Soil Taxonomy Pada Beberapa Statsiun Iklim di Kalimantan Timur. Fakultas Pertanian Universitas Mulawarman, Samarinda. 85 p.

Ohta, S., Syarief Effendi., N. Tanaka and S. Miura, 1992. Characteristics of Major Soils Under Lowland Dipterocarps Forest in East Kalimantan, Indonesia. Tropical Rainforest Research Project of JICA, Samarinda. 92 p.

Soil Survey Staff, 1975. A Basic System of Soil Classification for Making Interpreting Soil Surveys. Soil Conservation Service USDA, Washington DC (Hand Book No. 436). 754 p

Spaargaren, O.C. 1984. World reference base for soil Resources. International Society of Soil Science-International Soil reference and Information Centre-Food and Agriculture Organization of United Nations. Wegenengen / Rome. 161 p.

Sys, C. 1979. Regional Pedology. Tropical Soils II. ITC for Post-Graduate Soil Scientist. State University of Ghent, Belgium. 125 p.

Sys, C and E. Van Ranst, 1991. Regional Pedology. Soils of the Tropical and the Subtropics. International Training Centre for Post – Graduate Soil Scientist. State University of Ghent, Belgium. 125 p.

Sys, C., E. Van Ranst and J. Debaveye, 1991. Land Evaluation part I and II. International Training Centre for Post – Graduate Soil Scientist. State University of Ghent, Belgium. 521 p.

Sys, C., E. Van Ranst., J. Debaveye and F. Beernaert. 1993. Land Evaluation part III. Crop Requirements. International Training Centre for Post – Graduate Soil Scientist. State University of Ghent, Belgium. 199 p.