EUROPEAN UNION

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MINISTRY OF FORESTRY
AND ESTATE CROPS

LAND CAPABILITY OF LABANAN SOIL TO DEVELOPMENT OF RAINFEDS, PERENNIALS AND FOREST PLANTATIONS BASE ON SOIL CLASSIFICATION (USDA, 1992) AND LAND EVALUATION

(CASE STUDY TO SUITABILITY OF OIL PALM PLANTATION)

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In Association with

DHV Consultants B.V.

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(Competitive Award Scheme)

In evaluating the fertility of an area, there are some components that must be taken into account such as the quality and characteristics of the land. Based on the quality and characteristic of the land, the land suitability of an area is determined in the Orders, Classes, or even subclass levels.

1. Land suitability orders and classes

In general, land suitability can be divided into two orders and five classes were defined, namely :

1. Order Suitable (S) : use only 3 classes; they are S1 (Suitable), S2 (Moderately Suitable), and S3 (Marginally Suitable).
2. Order Unsuitable (N); use only 2 subclasses they are N1 (Actually unsuitable but potentially suitable); and N2 (Actually and potentially unsuitable).

2. The Land Suitability Subclasses

The subclasses are reflecting kinds of limitations, or main kinds of improvement measures required, within classes. They are indicated in the symbol using lower case letters which mnemonic significance. The following subclasses have been defined : **c** (climatic limitations), **t** (topographic limitations), **w** (wetness limitations), **s** (physical soil limitation/influencing soil or water relationship and management), **f** (soil fertility limitations not readily to be corrected), **n** (salinity and/or alkalinity limitations) (Sys and Van Ranst, 1991).

3. 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 Oil palm plantation of each soil mapping units as a specific land utilization types have been determined.

3.1. Climate

The optimum mean daily temperature for Oil palm is 22-30°C with the mean minimum temperature should be at least 18°C.

Oil palm performs well in region with a total annual precipitation of over 1700 mm/year, well distributed throughout the growing period, that have 2 or less consecutive dry months. Excessively rainfall decrease both the pollen density and the oil content of the mesocarp. In order to get high yields the annual number of sunshine hours should exceed 1300 hours/year.

The methodology suggest in the evaluation of the climate with as ultimate aim, the determination of climatic rating to be introduced in the overall evaluation. For this reason the climatic characteristics are grouped into 3 groups, they are : Characteristics related to rainfall, temperature and radiation.

For calculation of the climatic index the lowest characteristics rating of each group is used. This is because there is always a strong interaction between characteristics of the same group of climatic group and because they do not act together.

The climatic evaluations of the surveyed area show that the climatic characteristics such as annual rainfall, length of dry season, mean annual maximum, average daily minimum of the coldest month, mean annual temperature has an maximum value for oil palm. The annual sunshine hours (n/N) has moderate value, but the whole the climatic characteristics had optimum value by rating value 96.

3.2. Soils

Deep, permeable, well structure soils are most suitable for Oil palm cropping system. The required effective soil depth is > 1.00 m and the maximum rooting depth is 2.00 m.

Oil palm is sensitive to waterlogging. A groundwater levels at less than 0.90 m from the surface, lasting for more than 14 days should be avoided. If the land is flooded for over 1 week in 10 years, this land considered not suitable.

Clay and clay loam textures are optimal for Oil palm. Soils on alluvial deposits are preferred. Poorly drained soils with ironstone gravel, sandy coastal soils and deep (>0.50 m) peats are unsuitable.

The suitability classification of soil mapping units of the studied area according to land characteristics of the surveyed area compare to the land characteristics of Oil palm are mostly actually unsuitable, except on SMU3 which have Marginally Suitable (S3tf).

Table 7. Land Suitability subclasses (Actual) to Oil palm Plantation

Soil Mapping Units	Land Suitability Classification	Limiting Factors	Wide of area	
			Ha	%
1	N1tf	-Topography -Sums of basic cation -pH H20	225.52	8.99
2	S3tf	-Topography -Base saturaion -Sums of basic cation -pH H20	1304.61	52.01
3	N1tfs	-Topography -Texture -Sums of basic cation -pH H20	150.35	5.99
4	N1tfs	-Topography -Soil depth -Base saturation -Sums of basic cation -pH H20	414.45	16.53
5	N1tf	-Topography -Sum of basic cation -pH	413.45	16.48

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).

PREFACE

Soil surveyed report to Land capability of Labanan soil to development of rainfed, perennials and forest plantations base on soil classification (USDA, 1992) and land evalaution (FA), 1976) especially to suitability of Oil palm plantation has been started from February 1999 and submitted in the middle of June 1999.

This project is partly of the Berau Forest Management Project in East Kalimantan sponsored by European Union and Ministry of Forestry and Estate Crops of Indonesia through Competitive Award Scheme (Organized between BFMP and PT. Inhutani I).

The project site was set of Soil Laboratory of Agriculture Faculty Mulawarman University, Berau Forest Management Project and PT. Inhutani I. Location of the project situated in the part of concession forest area PT. Inhutani I Swakelola Labanan, Berau Regency of East Kalimantan Province, Indonesia.

The report is to be submitted to Berau Forest Management Project (European Union) and PT. Inhutani I (Ministry of Forest and Estate Crops) as a final report of the competitive award scheme project.

Samarinda, June 1999

Mulyadi
(Researcher/Soil surveyor)

IV. CONCLUSSIONS AND RECOMMENDATIONS

A. Conclusions

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, Aeric Tropaquepts; Fine silty, mixed, Isohyperthermic, Groassarenic Hapludults; Fine silty, mixed, Isohyperthermic, Typic Hapludults; Fine, mixed, Isohyperthermic, Typic Hapludults; Fine, mixed, Isohyperthermic, Typic Kanhapludults; Fine silty, mixed, Isohyperthermic, Typic Kandiudults; Fine, mixed, Isohyperthermic, Typic Kandiudults, and Fine, Kaolinitic, Isohyperthermic, Typic Kandiudults.

Base on the soil Family, size distribution, effective soil depth and topography classes; Soils are differentiated and grouped in Seri level (tentative) and used as Soil Mapping Units. They are Labanan Makarti, Labanan Makmur, Labanan Jaya, Tumbit Dayak and Tumbit Melayu Seri or correspond to SMU 1 to SMU 5.

Soil fertility evaluation and land suitability classification to 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.

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 Oil palm plantation showed that, the most limiting factors of the studied area are 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 Hog-back 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 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.

Rolling and hilly area is an important physical limiting factor of the mechanized Oil palm plantation. This area is still possible to be developed if Nucleus Estate System (NES) applied where the main farming (Nucleus) belongs to estate and produces from the surrounding farmers (Inhabitant) or invites farmers (Transmigration). If the land clearing doing by total clearing and hard hoeing, cropping terrace and legume cover crops is recommended because the total clearing will remove the litter/humus, vegetation and its roots, and this will accelerate the intensity and quality of soil erosion.

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Appendix

Criteria to evaluate Chemicals Soils Characteristics

Chemical Soils Characteristics	**Value and Status**				
	Very Low	**Low**	**Medium**	**High**	**Very High**
Organic Carbon (%)	< 1.00	1.00-2.00	2.01-3.00	3.01-4.00	> 5.00
Nitrogen (%)	< 0.10	0.10-0.20	0.21-0.50	0.51-0.75	> 0.75
C/N rasio	< 5	5-10	11-15	16-25	> 25
P205 Available (ppm) Bray	< 10	10-15	16-25	26-35	> 35
K20 Total (ppm)	< 100	100-250	250-1000	1000-2000	> 2000
K+ (meq/100 gr. Soil)	< 0.1	0.1-0.2	0.3-0.5	0.6-1.0	> 1.0
Na+ (meq/100 gr. Soil)	< 0.1	0.1-0.3	0.4-0.7	0.8-1.0	> 1.0
Ca2+ (meq/100 gr. Soil)	< 2	2-5	6-10	11-20	> 20
Mg2+ (meq/100 gr. Soil)	< 0.4	0.4-1.0	1.1-2.0	2.1-8	> 8
CEC (meq/100 gr. Soil)	< 5	6-16	17-24	25-40	> 40
Base Sat. (meq/100 gr. Soil)	< 20	21-35	36-50	51-70	> 70
Al. Sat. (meq/100 gr. Soil)	< 10	11-20	21-30	31-60	> 60

Soil Reaction (pH)	**Very Acid**	**Acid**	**Slightly Acid**	**Neutral**	**Slightly Alkalis**	**Alkalis**
pH (H20)	4.5	4.5-5.5	5.6-6.5	6.6-7.5	7.5-8.5	>0.85

Source : CSR, Bogor in Hardjowigeno (1992)

Appendix

Criteria to Soil Fertility Evaluation (TOR No. 59b, P3MT/CSR, 1983)

No.	CEC	BS	P205, K20, C-organic	Fertility Status
1.	T	T	> 2 T without R	High
2.	T	T	> 2 T with R	Medium
3.	T	T	> 2 S without R	High
4.	T	T	> 2 S with R	Medium
5.	T	T	T, S, R	Medium
6.	T	T	2 R with T	Medium
7.	T	T	2 R with S	Low
8.	T	S	2 T without R	High
9.	T	S	2 T with R	Medium
10.	T	S	2 S	Medium
11.	T	S	Other combination	Low
12.	T	R	2 T without R	Medium
13.	T	R	2 T with R	Low
14.	T	R	Other combination	Low
15.	S	T	2 T without R	Medium
16.	S	T	2 S without R	Medium
17.	S	T	Other combination	Low
18.	S	S	2 T without R	Medium
19.	S	S	2 S without R	Medium
20.	S	S	Other combination	Low
21.	S	R	3 T	Medium
22.	S	R	Other combination	Low
23.	R	T	2 T without R	Medium
24.	R	T	2 T with R	Low
25.	R	T	2 S without R	Medium
26.	R	T	Other combination	Low
27.	R	S	2 T without R	Medium
28.	R	S	Other combination	Low
29.	R	R	All combination	Low
30.	SR	T, R, S	All combination	Very low

Notes : T = High R = Low
S = Medium SR = Very low

Appendix

Estimation of the Super dolomit Need to base Saturation 30 %

CEC of Soil	Sum of Bases	Base Saturation	Bases Needed	Super dolomite needed	
				Gram/crop	Kg/ha
< 10	3.00	30	-	-	-
	2.50	25	250	250	125
	2.00	20	500	500	250
	1.50	15	750	750	375
	< 1.00	< 10	1 000	1 000	500
10 - 15	4.50	30	-	-	-
	3.75	25	375	375	187.5
	3.00	20	750	750	375.0
	2.25	15	1 125	1 125	562.5
	< 1.50	< 10	1 500	1 500	750.0

Source : Pusat Perkebunan Marihat, Medan

CLIMATIC REQUIREMENTS - OIL PALM

Climatic Characteristics	Climatic class, limitation and rating scale					
	S1		S2	S3	N1	N2
	0	1	2	3	4	
	100 95	85	60	40	25	0
Annual rainfall (mm)	> 2000	2000-1700	1700-1450	1450-1250	-	< 1250
Length dry season (months) P < 1/2 PET	0-1	1-2	2-3	3-4	-	> 4
Mean annual max. temp. (°C)	> 29	29-27	27-24	24-22	-	< 22
Average daily min. temp. coldest month (°C)	> 20	20-18	18-16	16-14	-	< 14
Mean annual temp. (°C)	> 25	25-22	22-20	20-18	-	< 18
Annual n/N	> 0.75	0.75-0.45	< 0.45	-	-	-

LANDSCAPE AND SOIL REQUIREMENTS - OIL PALM

Land Characteristics	Class, degree of limitation and rating scale.					
	S1 0	S1 1	S2 2	S3 3	N1 4	N2
	100 – 95	95 – 85	85 – 60	60 – 40	40 – 25	25 – 0
Topography (t)						
Slope	0-4	4-8	8-16	16-30	30-50	> 50
Wetness (w)						
Flooding	Fo	Fo	F1	F2	-	F3+
Drainage (4)	moderate	good	imperf.	poor and aeric	poor, but drainab	poor, not drainab
(5)	imperf.	moderate	good			
Physical soil characteristics (s)						
Texture/struct.	C>60s, C<60s SiCs	SiCL,Co CL,SC,L	SCL	SL,LfS	-	Cm,SiCm LS,LcS, fS,S,cS
Coarse fragm(vol%) in depth	0-3	3-15	15-35	35-55	-	> 55
Soil depth (cm)	> 150	150-100	100-50	50-25	-	< 25
$CaCO_3$ (%)	0	0-1	1-5	5-10	-	> 10
Gypsum (%)	0	0-0.5	0.5-2	2-3	-	> 3
Soil fertility characteristics(f)						
Apparent CEC (cmol(+)/kg clay)	> 16	< 16(-)	< 16(+)	-	-	-
Base saturation(%)	> 35	35-20	< 20	-	-	-
Sum of basic cations (cmol(+)/kg soil)	> 5	5-3.5	3.5-2	< 2	-	-
pH H_2O	5.8-5.5	5.5-5.0	5.0-4.2	4.2-3.5	< 3.5	-
	5.8-6.0	6.0-6.5	6.5-7.0	7.0-7.5	-	> 7.5
Organic carbon(%)	> 1.2	1.2-0.8	< 0.8	-	-	-
Salinity and Alkalinity (n)						
ECe (dS/m)	0-1	1-2	2-3	3-4	4-8	> 8
ESP (%)						

Appendix

Profile pits

Contents

Profile No.	1.	Fine, Mixed, Isohyperthermic, Typic Kandiudults
	10.	Fine silty, Mixed, Isohyperthermic, Typyc Kandiudults
	14.	Fine, Mixed, Isohypethermic, Typic Kanhapludults
	38.	Fine, Kaolinitic, Isohyperthermic, Typic Kandiudults
	47.	Fine silty, Mixed, Isohyprthermic, Typic Kandiudults
	50.	Fine, Mixed, Isohyperthermic, Typic Kandiudults
	55.	Fine, Mixed, Isohyperthermic, Typic Hapludults
	55b.	Coarse loamy, Mixed, Isohyperthermic, non-calcareous, Aeric Tropaquepts
	63.	Fine silty, Mixed, Isohyperthermic, Grossarenic Hapludults
	68.	Fine, Kaolinitic, Isohyperthermic, Typic Kandiudults
	73.	Fine silty, Mixed, Isohyperthermic, Typic Hapludults

Mini pits : Total 64 observation points.

Glossary of horizon Designation (Sources : Agric. Handbook No. 18).

Master Horizons and layers :

O Horizon : Layers dominated by organic material, except limnic layers that are organic.

A Horizon : Mineral horizons that formed at the surface or below an O horizon and : (1) are characterized by an accumulation of humified organic matter intimately mixed with the mineral fraction and not dominated by properties characteristic of E or B horizons; or (2) have properties resulting from cultivation, pasturing, or similar kinds of disturbance.

E Horizons : Mineral horizon in which the main feature is loss of silicate clay, iron, aliminium, or some combination of these, leaving a concentration of sand and silt particles of quarzt or other resistant materials.

B Horizons : Horizon that formed below an A, E, or O Horizon and are dominated by : (1) carbonates, gypsum, or silica, alone or in combination; (2) evidence of removal of carbonates; (3) concentrations of sesquioxide; (4) alterations that form silicate clay; (5) formation of granular, blocky, or prismatic structure; or (6) combination of these.

C Horizons : Horizons or layers, excluding hard bedrock, that are little affected by pedogenic processes and lack properties of O, A, E, or B horizons. Most are mineral layers, but limnic layers, whether organic or inorganic, are included.

R layers : Hard bedrock including granite, basalt, quartzite and indurated limestone or sandstone that is sufficiently coherent to make hand digging impractical.

Transitional Horizons

AB- A horizon with characteristics of both an overlying A horizon and an underlying B horizon, but which is more like the A than the B.

BC-A horizon with characteristics of both an overlying B horizon and an underlying C horizon, but which is morelike the B than the C.

Subordinate Distinctions within Master Horizons and Layers

h-Illuvial accumulation of organic matter in the form of amorphous, dispersible organic matter-sesquioxide complexes where sesquioxide are in very small quantities and the value and chroma of the horizon are less than 3.

t-accumulation of silicate clay that either has formed in the horizon and is subsequently translocated or has been moved into by illuviation.

w-Development of color or structure in a horizon but with little or no apparent illuvial accumulation of materials.

General site Description

1. **Information on the site**

Profile number : 1
Location : In between transect BD Labanan, Berau
Coordinate : 117° 15' 37.6" E and 2° 00' 12" N
Land system : TWH/MPT
Landform
a.Physio. Position : middle slope
b.Surround. Landform : Undulating to rolling
Slope : 15 % Length of Slope : 40-60 m Slope form : concave
Vegetation : Log over stand (Secondary forest)
Author : Arham
Date : 19-2-99

2. **General information on the soil**

Parent material : Conglomerate over sandstone
Drainage : Well drained
Effective soil depth : Deep
Depth to groundwater : Deep
Pedon Classification : **Fine-Mixed-Isohyperthermic-Typic Kandiudults**

Depth (cm)	Horizon	Profile description
`0-31	Ah	Light yellowish brown (10 YR 6/4); sandy loam; sub angular blocky, fine, weak; very friable (moist); common organic matter; common fine, medium and coarse roots; common medium and coarse pores; clear smooth boundary
31-42	AB	Yellow (10 YR 7/6); sandy loam; sub angular blocky, fine, weak; friable (moist); low organic matter; common medium and coarse roots; common medium and fine pores; clear smooth boundary to
42-56	B1	Reddish yellow (7.5 YR 7/8); sandy clay loam; sub angular blocky, medium, moderate; slightly firm (moist); low organic matter; common medium and coarse roots; common fine, few medium and coarse pores; gradual smooth boundary to
56-78	Bt1	Reddish yellow (7.5 YR 6/8); sandy clay; sub angular blocky, medium, moderate; slightly firm (Moist); few thin clay skin on pedfaces; few fine and medium roots; common fine pores; clear smooth boundary to
78-110	Bt2	Strong brown (7.5 YR 5/8); clay; sub angular blocky, medium moderate; firm (moist); common thin clay skin on pedfaces; few fine roots; few fine and medium pores; clear smooth boundary to
110-145	Bt3	Reddish yellow (5 YR 6/8); clay; sub angular blocky, coarse, moderate; very firm (moist); few thin clay skin on pedfaces; few fine roots; common fine pores; clear smooth boundary to
145-180	BC	Red (2.5 YR 5/6) and pinkish gray (7.5 YR 7/2) common, fine, distinct mottles of color parent materials; sandy clay; sub angular blocky, medium, moderate; firm (moist); few fine roots and pores.

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Finally author would like to express his sincerely thanks to European Union and Ministry of Forestry and Estates Crops to facility available award for competitive award scheme in Labanan, Berua, East Kalimantan Indonesia.

EXECUTIVE SUMMARY

A Semi detailed land capability study is presented for about 2508.59 Ha at concession forest Area of PT. Inhutani I Labanan, Berau, East Kalimanatan. The survey area 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. Base on soil Family, size distribution, effective soil depth and topography classes; soils are differentiated and grouped in five tentative Seri level and used as Soil Mapping Units, They are Labanan Makarti, Labanan Makmur, Labanan Jaya, Tumbit Dayak, and Tumbit Melayu.

Soil fertility evaluation and land suitability classification are recognized on soil mapping units to Oil palm plantation. In general showed that the most limiting factors are low to very low cation exchange capacity, Base saturation and sum of basic cation. Aluminium saturation, although it may vary 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 for 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 Oil palm are **Marginally suitable (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 by topography, sum of basic cation and pH limiting factors. Actually **unsuitable (N1tfs)** on soil mapping units 3 by topgraphy, 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 main limiting factors to Oil palm plantation of the whole surveyed area are the high range of topographic classes, soil fertility characteristics and physical soil characteristics. To developed Oil palm plantation on the certain area, advisable to use the Nucleus Estate System (NES). 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 soils rather than burning should propagate during land clearing activity. Soil acidity and phosphorous fixation can be improve by liming.

I. INTRODUCTION

A. Background of the study

Agriculture is one of the sectors that always take the Government's program, while the population live and theirs living in this sector. To accelerate its developments it is necessary to do some efforts such Intensification, Extensification and diversification.

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 precession, 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 Oil palm plantation which will be developed by PT. Inhutani I/Berau Forest Management Project (BFMP) is important commodities that can be support the increase of regional income of Berau Government and new field work for inhabitant of surrounding area.

In the guarantee of the success of the Oil palm plantation in this area, it is necessary to know the potentiality of area by conducting the survey. A semi detailed soil survey have been done on the selected area of about 2000 hectares in the Labanan Forest of Inhutani I concession forest area, Berau Regency. The data needed, related to the land characteristics, soil fertility, and landform including topography, climate, hydrology, development infrastructure and other factors that support the development of Oil palm plantation.

B. Objective of the research

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 objectives of the research are to evaluate of Labanan area and to determine what kinds of limiting factors for the use of the soil, especially for Oil palm Plantation.

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

III. RESULT

A. 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.

Altitude within the study area ranges from a few meters above sea level (a.s.l) at the riverbank of Tumbits river to more than 100 meters a.s.l. along the hills in the East. This area is situated on the left side of the main road, which connects Tg. Redeb and Samarinda or located exactly about km 10 to km 16 from Labanan sub-district.

The survey area can be reached easily by car from Tg. Redeb just about 45 km to the outside of the South-West part Tg. Redeb.

B. 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 km2 .

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.

C. Climate

1. 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.

2. 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.

3. 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.

3.1. 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/cm^2 /day) has the highest value in April (545.5 g cal/cm^2/ day) and the lowest in January (292 g cal/cm^2 /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.

Winds are generally light and bright. Mean wind speeds have been measured at 2.00 m above land surface. The highest wind speed is in 6 knot and the lowest 3 knot.

3.2. Soil climatic regime

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

In the Berau Regency, the SMR is closely related to the rainfall and physiograpic position. The SMR of the survey area is Udic SMR. The whole meteorological stations of East Kalimantan which have been computed according to Newhall Simulation System, have a Isohyperthermic SMR. Indeed, the area, located in the Intertropical belt, has a difference between the mean summer and the mean winter temperature less than 2° C.

3.3. Climatic Evaluation According to Papadakis

The climatic classification of Papadakis (1970) is a system in which a classification of climates and an ecological classification of crops fit one another, and has been prepared with special reference to agricultural potentialities. On the basis of elemental climatic data average daily maximum, average daily minimum and average of the lowest temperature, vapour pressure and rainfall, month by month – climatic diagnostics are computed, and the climate is classified. Each classification unit corresponds definite agricultural potentialities; the classification point out automatically the possibilities and limitations of the climate for each crop, and type of agriculture.

Based on the climatic data of Berau station climate (table 1), the survey area has total rainfall of about 2001.33 mm/year and the Potential Evapotranspiration (PET) of 1907 mm/year. Most of the month has humidity index greater than 1.0 that's mean that all the month doesn't have drought stress and frost season, has total surplus or leaching rain about 904.3 mm/year. According to Papadakis classification, the climate of the survey area to suitability of world climate for equatorial crops is good for Coconut, Oil palm and Hevea; too humid for Cocoa.

Table 1. Climatic records, monthly mean or totals (Kalimarau, Berau 1984-1997)

02° 09’ 37’’ N Latitude and 117° 26’ 09” E Longitude

	Temperature ° C			Rainfall (mm)		Sunshine (hours)		Radiation	PET (mm/day)		Relative Humidity (%)		
Month	Max.	Min.	Mean	Total	Days	N	n/N	G cal/cm^2/day	Month	Days	Max.	Min.	Mean
January	32.72	20.81	26.79	231.98	21.4	3.41	0.32	292.0	112.8	3.64	98.0	71.4	84.7
February	30.70	22.46	25.58	228.77	18.6	3.69	0.31	352.2	89.6	3.20	97.7	70.6	84.2
March	31.22	22.61	26.92	204.76	19.0	4.30	0.36	349.9	84.6	2.73	98.1	69.2	83.7
April	32.16	23.07	27.62	152.77	13.6	5.48	0.46	545.5	90.1	3.00	98.2	68.9	83.6
May	32.46	23.23	27.85	165.14	14.1	5.60	0.47	297.2	81.0	2.94	98.1	68.5	83.3
June	32.47	23.11	27.79	136.11	12.6	5.84	0.49	300.5	84.3	2.81	98.0	66.2	82.1
July	32.46	22.59	27.53	111.81	11.0	6.22	0.52	307.4	86.0	2.77	97.9	63.0	80.5
August	32.53	22.59	27.56	111.48	11.8	6.54	0.54	336.1	98.9	3.19	98.0	64.2	81.1
September	32.46	22.69	27.58	110.33	10.7	5.37	0.45	310.1	85.7	2.86	98.0	64.4	81.2
October	32.54	22.71	27.62	159.75	13.9	5.03	0.42	366.4	97.3	3.14	98.1	66.0	82.1
November	31.89	22.60	27.25	193.52	18.5	4.72	0.39	353.8	102.6	3.42	98.0	66.5	82.3
December	31.06	22.51	26.79	194.92	19.9	3.71	0.31	300.6	84.1	2.71	98.0	69.8	83.9
	32,56						0.42						
Total			27,24	2001					1097				

D. 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.

E. 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.

F. 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.

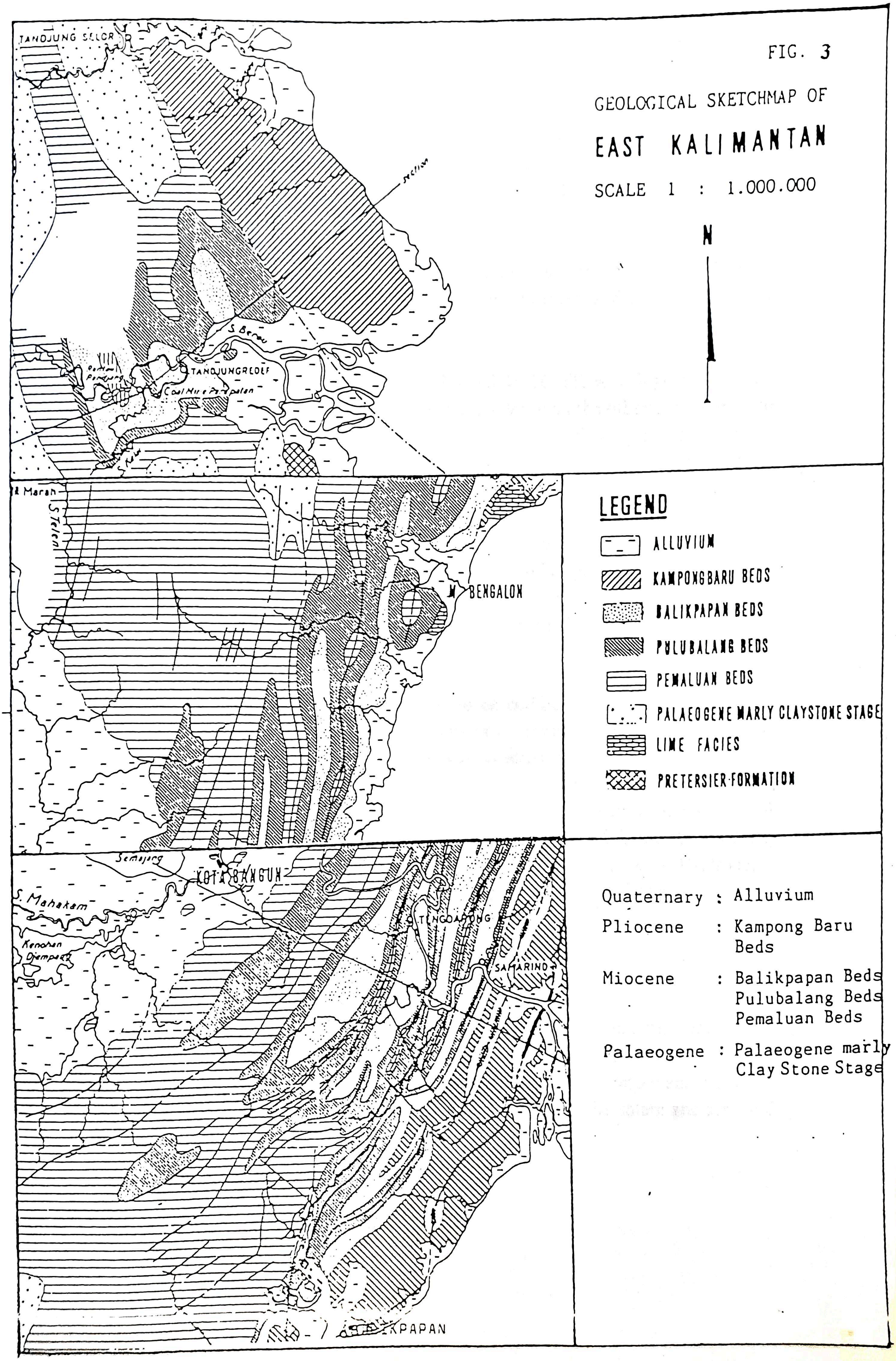


FIG. 3

GEOLOGICAL SKETCHMAP OF

EAST KALIMANTAN

SCALE 1 : 1.000.000

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.

The upper boundary of the Argillic/Kandic horizons were shallow (13-26 cm). The lower boundary varied mostly from 67 cm to 150 cm deep, and its depth could be related neither with texture nor with topography.

In general, the Bt horizon color were 7.5 YR to 10 YR with higher value and chroma. However, some soil in foot slopes were Yellower than the others. This leads to the assumption that although the color of the subsoil's is associated primarily with the texture, soil moisture condition as a reflection of geomorphology influence the soil color too.

Stronger structural development was recognized. In the upper and middle horizon sub angular blocky structure was dominant and easily broken to further into, fine sub angular blocky to crumb under weak pressure especially, soil were closely to its parent materials. In the C horizon, some soil has prismatic structure closely to rock structure of weathered sandstone parent materials.

In the upper part, thin clay skin are coated on pedfaces continuously, and were thicker in the middle part of Argillic/Kandic horizons. Some clay skin also occurs on root channels and macro pores caused of the biological activity.

The soil in this area are classified into five different Taxonomic subgroup level (USDA, 1992). Most of dominant soils in this area are classified Typic Kandiudults, Typic Hapludults, Grossarenic Hapludults and Aeric Tropaquepts, Aquic Dystropepts were classified soil the found on valley bottom. These soils were dropped into eight different Taxonomic of Family level (table 2).

G. Clay mineralogy on soil control section

Relatively resistant phyllosilicates and less weatherable minerals are almost invariable predominant in clay fraction. Destructive and constructive processes involving these components dominate the fraction. Particularly important are these processes that have a major role in determining characteristics of the solum and kind and distribution of minerals.

Two profiles a topsoil and subsoil samples in the surveyed area have been analyzed for type of clay minerals by Stephan Mantel (BFMP, 1998). Laboratory data showed that kaolinite is the dominant clay mineral in these profiles.

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.

Table 2. Taxonomic soils differentiation on Family level of surveyed area (USDA, 1992; World Reference Base/WRB, 1994 and Center for Soil Research, Bogor/CSR, 1983)

Soil Classification			Profile Number
USDA, 1992	**WRB, 1994**	**CSR, 1983**	
Coarse loamy, Mixed, Non-calcareous, Isohyperthermic, Aeric Tropaquepts	**Haplic Gleysols**	**Kambisol Gleiik**	**55b**
Fine silty, Mixed, Isohyperthermic, Grossarenic Hapludults	**Haplic Acrisols**	**Podsolik Haplik**	**63**
Fine silty, mixed, Isohyperthermic, Typic Hapludults	**Haplic Acrisols**	**Podsolik Haplik**	**73**
Fine, Mixed, Isohyperthermic, Typic Hapludults	**Haplic Acrisols**	**Podsolik Haplik**	**55**
Fine, Mixed, Isohyperthermic, Typic Kanhapludults	**Haplic Acrisols**	**Podsolik Kandik**	**14**
Fine silty, Mixed, Isohyperther-mic, Typic Kandiudults	**Haplic Acrisols**	**Podsolik Kandik**	**10 47**
Fine, Mixed, Isohyperthermic, Typic Kandiudults	**Haplic Acrisols**	**Podsolik Kandik**	**1 50**
Fine, Kaolinitic, Isohyperthermic, Typic Kandiudults	**Haplic Acrisols And Humic Ferralsols**	**Posolik Kandik**	**38 68**

H. 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.

A soil association is a regrouped of named and defined taxonomic units, which are geographically associated according to defined topographic relationship with a well known proportion of the taxonomic units within the mapping unit. A soil complex is a regrouped of named and defined taxonomic units which have no geographic distribution pattern.

Each soil mapping units provides the soil characteristics such as : Location, distribution, physiography, landform, slopes, parent materials, soil depth and wide of area.

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.

Table 3. Differentiation of Soil Mapping Units of the Surveyed Area

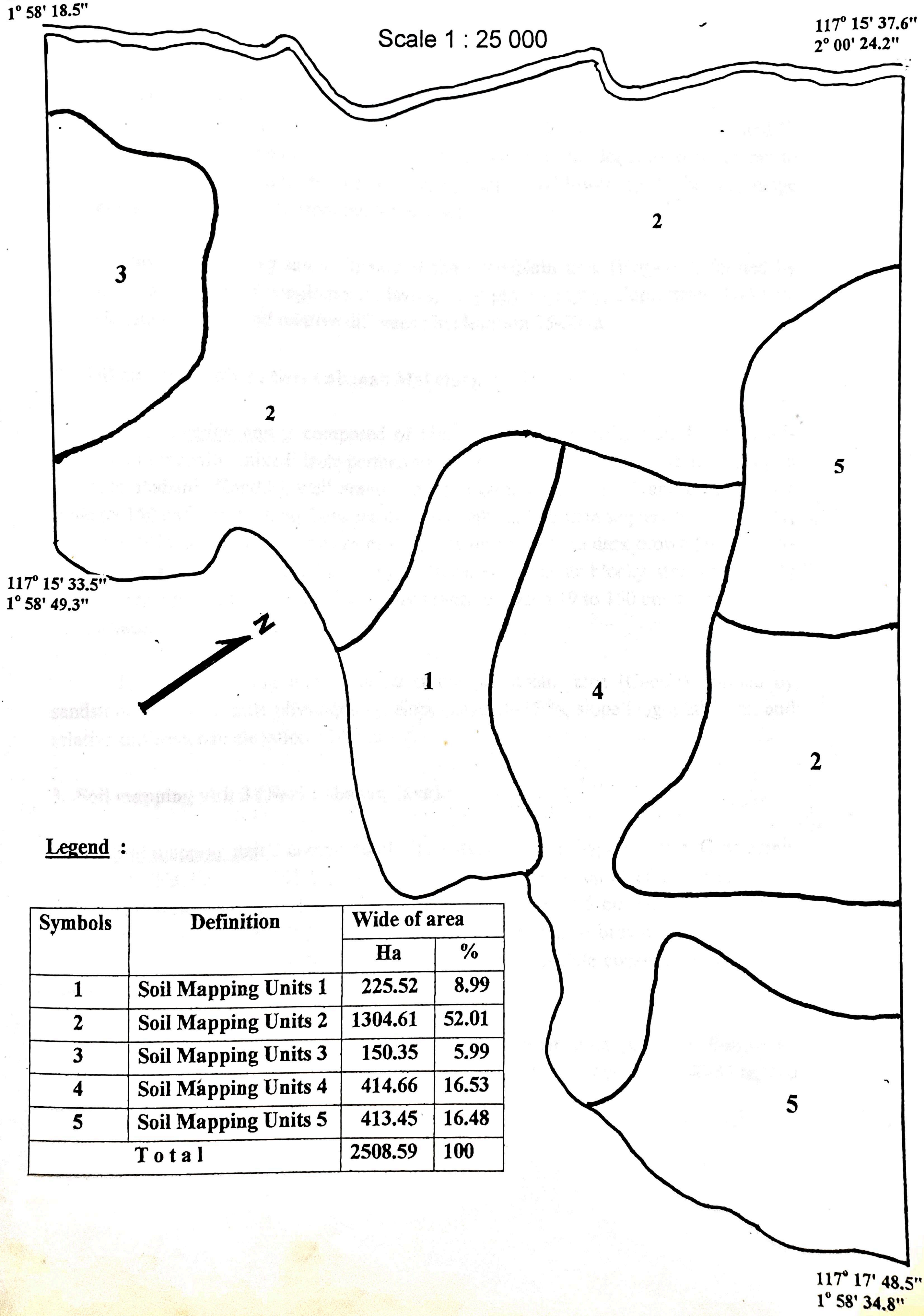
Map Unit	Soil Classification		Physio-graphy	Land Form	Slope (%)	Soil Depth (cm)	Parent Materials	Wide of Area (Ha)
	Seri (tentative)	Family						
1.	Labanan Makarti	Fine, Kaolinitic, Isohyperthermic, Typic Kandiudults	Rolling to hilly	Cues-ta	26-40	> 150	Sandstone with seam of conglo-merate	225.52
2.	Labanan Makmur	Associations of fine, mixed, Isohy-perthermic, Typic Kandiudults and Fine silty, Mixed, Isohyper-thermic, Typic Kandiudults	Rolling to hilly	Cues-ta	16-25	> 150	Sandstone	1304.61
3.	Labanan Jaya	Fine silty, Mixed, Isohyperthermic, Grossarenic Hapludults	Rolling to hilly	Cues-ta	26-40	> 150	Sandstone	150.35
4.	Tumbit Dayak	Fine, Mixed, Isohyperthermic,Typic Hapludults by Inclusion of Coarse loamy, Mixed, non-calcareous, Iso-hyperthermic Aeric Tropaquepts	Hilly	Hog-back	41-60	50-100	Sandstone with seam of conglo-merate near the surface	414.66
5.	Tumbit Melayu	Association of Fine, Mixed, Isohy-perthermic, Typic Kanhapludults and Fine silty, Mixed, Isohyperther-mic, Typic Hapludults by Inclusion of Coarse loamy, Mixed, Isohyper-thermic, Aquic Dystropepts	Hilly	Hog-back	41-60	100-150	Sandstone with seam of conglo-merate near the surface	413.45

Relief 11-50 m

750 m

Figure 4

SOIL MAP UNITS OF THE SURVEYED AREA



Legend :

Symbols	Definition	Wide of area	
		Ha	%
1	Soil Mapping Units 1	225.52	8.99
2	Soil Mapping Units 2	1304.61	52.01
3	Soil Mapping Units 3	150.35	5.99
4	Soil Mapping Units 4	414.66	16.53
5	Soil Mapping Units 5	413.45	16.48
Total		2508.59	100

1. **Soil mapping unit 1 (Seri Labanan Makarti).**

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, Bt1, 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.

2. **Soil mapping unit 2 (Seri Labanan Makmur).**

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 table (> 150 cm), Ah horizon between 4-7 cm depth, and horizon sequence Ah, AB, Bt1, Bt2, 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.

3. **Soil mapping unit 3 (Seri Labanan Jaya).**

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, Bt1, Bt2, Bt3, BC and C, pale brown to brown (10 YR 7/4-5/3) topsoils 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.

4. **Soil mapping unit 4 (Seri Tumbit Dayak).**

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, Bt1, 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 layers near the surface, hilly physiography, slope range 41-60 %, slope length 40-60 m, and relative difference in elevation 25-50 m.

5. **Soil mapping unit 5 (Seri Tumbit Melayu).**

Soil mapping unit 5 composed of Fine, mixed, Isohyperthermic, Typic Kanhapludults and Fine silty, mixed, Isohyperthermic, Typic Hapludults (Haplic Acrisols/Podsolik Kandik and Podsolik Haplik), 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, Bt1, 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.

I. Sources of Plant Nutrients

1. Total Carbon

Organic matter is the most important product of forest vegetation in the Tropical Rainforest climate of East Kalimantan.

The amount of organic matter immobilized in this area varies from 150 to 300 tons of dry materials per hectare containing 1.5 to 2 tons of mineral salts. The annual gain at the soil surface is estimated at about 15 tons dry materials per hectar containing approximately 200 kg of Nitrogen, 250 kg of mineral salts and 250 kg of Silica (Sys, 1979).

Generally the total carbon contents in the surveyed area decrease by incresing the depth. They are accumulated in the Ah or A horizon (0-10 cm) layers, then fell gradually in the deeper subsoils. Since the vegetation and climate is uniform, the litter supply and its conservation rate into the soil organic C are supposed to be similar among the soil, thus, the differences of C level in the surface soils be presumably be associated with the decomposition rate of soil organic matter.

Base on the table 4, the organic C contents show low level in the upper 0-20 cm depth and very low level in the 20-40 cm and 40-100 cm from the surface. The organic C contents at the deep of 0-20 cm depth is range between 1.8 to 1.21 %.

2. Nitrogen

The Nitrogen in soil organic matter remains the most important sources of Nitrogen for crop production in the Tropical Rainforest climate. The annual addition of fresh organic matter is about 3-15 tons/ha under a heavy rainforest. The depth function of total Nitrogen content in the surveyed area basically similar to that of organic matter content.

The total Nitrogen content were very low at the whole of determined Soil mapping units of the surveyed area or correspond to 544 - 840 kg/ha. Suppose the annual decomposition rate of soil organic 2-5 percent (mean 4 %), from this point of view, the available Nitrogen in the surface soil range 21.76 to 33.6 kg/ha only.

The quality of organic matter expressed in the C/N ratio, and the C/N ratio of the soil range from 9 to 25 which are good to low quality level. Mostly, the status of C/N ratio in the 0-20 cm and 20-40 cm depth belong to low level, that's mean that the organic matters still in the decomposition process.

3. Phosphorous (P)

The available P ($P_2 0_5$) levels was markedly higher in the shallow solum than in the deeper ones. The higher levels of available P in the topsoils are partly caused of the organic C contents. Available phosphorous levels in the surveyed area are generally low to very low.

The chemical data showed that with increasing weathering, the total P content of the soil increase but the available P decrease. Moreover, an important part of phosphorous in the soil is fixation by the sesquioxides during weathering process and becomes practically unavailable for plant nutrition. Therefore, phosphorous fixation is recognized as a major problem to agricultural development. Phosphorous in the surveyed area is present as organic phosphorous and mineral, but most of the mineral phosphorous is unavailable for plant nutrition.

Since most phosphorous in the surveyed area is organic, the agricultural practices which favorable the decomposition of humus result in an accelerated release of P the soil solution. Liming may have such effect when this is combined with the neutralization of exchangeable aluminium and the decrease of positive charges, and its may significantly increase the amount of available phosphorous.

Table 4. Storages and status Organic C, Total and available N.P.K.

Elements	Depth (cm)	Soil Mapping Units				
		1	2	3	4	5
Organic C (%)	0-20	1.50 (L)	1.31 (L)	1.21 (L)	1.33 (L)	1.84 (L)
	20-40	0.81 (VL)	0.52 (VL)	0.58 (VL)	0.35 (VL)	0.47 (VL)
	40-100	0.37 (VL)	0.27 (VL)	0.32 (VL)	0.29 (VL)	0.32 (VL)
Total N (%)	0-20	0.06 (VL)	0.08 (VL)	0.06 (VL)	0.07 (Vl)	0.07 (VL)
	20-40	0.04 (VL)	0.04 (VL)	0.03 (VL)	0.02 (VL)	0.03 (VL)
	40-100	0.02 (VL)	0.03 (VL)	0.02 (VL)	0.03 (VL)	0.02 (VL)
C/N ratio	0-20	25 (L)	16 (L)	20 (L)	14 (L)	26 (L)
	20-40	20 (L)	13 (M)	14 (L)	18 (L)	16 (L)
	40-100	19 (L)	9 (G)	16 (L)	10 (M)	16 (L)
Available P (ppm)	0-20	10.88 (L)	14 (L)	12.6 (L)	10.3 (L)	18.7 (M)
	20-40	5.20 (VL)	11 (L)	10.8 (L)	5.4 (VL)	14.9 (L)
	40-100	3.50 (VL)	7 (VL)	7.4 (VL)	2.7 (VL)	8.4 (VL)
Total P (ppm)	0-20	561 (VH)	533 (VH)	155 (VH)	261 (VH)	287 (VH)
	20-40	503 (VH)	505 (VH)	124 (VH)	352 (VH)	232 (VH)
	40-100	524 (VH)	640 (VH)	144 (VH)	474 (VH)	248 (VH)
Available K (ppm)	0-20	31 (M)	55 (H)	44 (H)	14 (L)	27 (M)
	20-40	34 (M)	54 (H)	35 (M)	13 (L)	34 (M)
	40-100	45 (H)	32 (M)	22 (M)	4 (L)	36 (M)
Total K (ppm)	0-20	378 (VH)	1223(VH)	404 (VH)	435 (VH)	755 (VH)
	20-40	307 (VH)	424 (VH)	542 (VH)	330 (VH)	545 (VH)
	40-100	487 (VH)	821 (VH)	521 (VH)	546 (VH)	542 (VH)

Notes : VL = Very low M = Medium VH = Very High
L = Low H = High G = Good

J. Physicho-chemical properties

In general, the chemical properties were reasonably more influence by Genesis and texture of the soils other than by the physiograhy. The cation retention (CEC) and charge properties related to the silicate clay minerals, the organic matter and the sesquioxides.

Base on the clay mineralogy studied by BFMP and identification of clay mineralogy by CEC clay (after correction by CEC of organic matter), the dominant clay mineralogy of the studied area was Kaolinite with low content of smectite.

They are no substitution in kaolinite and the permanent negative charge sites are few. Hapludults clay of the surveyed area have a higher permanent charge than Kandiudults. Within the Kandiudults, the mixed clay mineralogy is higher than kaolinite layers. During the weathering process, this charge becomes saturated with alumina. The permanent charge expressed by the sum of bases and extractable alumina or equivalent to Cation Exchange Capacity of Clay (ECEC).

The organic matter concentrated at the surface were the charges is negative and depending charge, it has been stated that generally, the CEC of hundred gram organic C equal to 260 meq at pH 7 and 35 meq/100 gram C at pH 3.5.

Most of the soil mapping units has low to very low CEC, sum of bases cation, and Base saturation. This mean that, to maintain organic matter in the topsoils is mostly important to conserve and improve soil fertility in natural but its can be combine by liming and fertilizer application.

K. Acidity and associated Al-problems

Acidity is a major limitation for intensive agricultural throughout the Tropical Rainforest Climate. Specific factors for low yields on acid soils include Al and Mn toxicity and deficiencies or imbalance among the basic cation.

The pH (H_20) mostly increased in the top portions, then gradually decreases in the sub horizons with depth, but generally acid to very acid, except on the soil mapping units 1 at the depth of 40-100 cm where grouped into slightly acid. While the pH (KCl) kept almost same level in the top and subsoils. The delta pH (pH H_20-KCl) was always negative, that's mean the dominant charge properties of the soils is negative charges.

Burning of natural vegetation which mostly done by inhabitant to agriculture practice (shifting cultivation) can improve Al status of the soils.

Shifting cultivation is agriculture practice in the Labanan area that normally without use of fertilizers and lime. Burning of natural vegetation is the only possibility to neutralize the acidity induced by Al.

Some researchers said that burning of 1 ha of vegetation on Tropical Rainforest can liberate important amount of basic cations (Ca, Mg) which can be used to replace the alumina in the exchange complexes. The estimated of Ca, Mg liberated from burning vegetation is about 138.450 meq or equal to neutralize 4.6 meq Al/100 gram soils (Sys and Van Ranst, 1991). Application of phosphorous and liming, can also do improve Al status of the soil.

Table 5. Storages and status Soil Reaction pH), CEC, Sum of Base, Base Saturation and Aluminium Saturation.

Elements	Depth (cm)	Soil Mapping Units				
		1	2	3	4	5
PH (H_2O)	0-20	4.41(VA)	4.31(VA)	4.45(VA)	4.66 (A)	4.31 (VA)
	20-40	4.55 (A)	4.50 (A)	4.56 (A)	4.50 (A)	4.50 (A)
	40-100	4.70 (SA)	4.61 (A)	4.69 (A)	4.83 (A)	4.61 (A)
PH (KCl)	0-20	3.64	3.60	3.80	3.70	3.60
	20-40	3.70	3.75	3.80	3.60	3.75
	40-100	3.66	3.66	3.80	3.60	3.66
CEC (meq/100 gr)	0-20	5.77 (L)	8.05 (L)	5.47 (L)	11.0 (L)	8.02 (L)
	20-40	6.01 (L)	6.84 (L)	4.73 (VL)	9.65 (L)	6.84 (L)
	40-100	4.15 (VL)	6.10 (L)	4.05 (VL)	4.321 (L)	6.10 (L)
Sum of bases (meq/100mg)	0-20	1.90	1.51	1.73	1.43	1.51
	20-40	1.42	1.23	1.49	1.02	1.23
	40-100	1.08	1.50	1.17	1.72	1.50
Base Satura-tion (%)	0-20	32.9 (L)	18.8 (VL)	29.5 (L)	13.0 (VL)	18.7 (VL)
	20-40	23.6 (L)	18.2 (VL)	31.5 (L)	10.6 (VL)	18.2 (VL)
	40-100	26.0 (L)	24.6 (L)	28.8 (L)	18.5 (VL)	24.6 (L)
Al Saturation (%)	0-20	39.7 (H)	36.4 (H)	34.7 (H)	29.1 (M)	36.4 H)
	20-40	34.6 (H)	48.8 (H)	48.2 (H)	63.2 (H)	48.8 (H)
	40-100	84.5 VH)	78.1 (VH)	70.7(VH)	40.7 (H)	78.1 (VH)

Notes : VL = Very low   M = Medium   VH = Very High
L = Low   H = High
VA = Very acid   SA = Slightly Acid   A = Acid

L. Soil Fertility

The growth of plants generally is influenced by many factors such as climate, water availability and soils. Soil is one of the environmental dominant factors against the growth of plants both as growth media and nutrients supply. Generally known that the more soil fertility, the better plant growth and the higher yield expectation.

The evaluation of soil fertility is the determining nutrient supply needed by plants. The evaluation base on the analysis result of soil samples or on the visual observation at site such as the kind and type of vegetation, slope, soil texture, parent materials, and climate (rainfall and temperature).

The surveyed area with the Tropical rainforest (Afa) climate is the region which has been intensively decomposed so that the base cations and silica leached out during decomposition time and caused the soil less fertile and acid.

The natural fertility of the soil at the surveyed area is generally concentrated on organic matter at top soils which are immobilized in the vegetation and the others source of fertility are come from decomposition of parent materials.

Based on the observation at the site and soil nutrients status at 0-20, 20-40 cm and 40-100 cm depth, soil fertility evaluation showed that most of the soil has low fertility because of low status of cation exchange capacity, Base saturation, C-organic, and P_20_5 contents. At the 20-40 cm depth on Soil mapping unit 3, the soils showed that the fertility evaluation has very low soil fertility because of very low status of cation exchange capacity (see table 6).

The main problem related to soil fertility of the surveyed area for Oil Palm plantation is the basic cation especially, bivalent cation such as Ca^{++} and Mg^{++} , organic matter in topsoils and the high phosphorous fixation capacity.

Kebun Marihat Medan suggested that if the sum of basic cation ranges between 2.0-1.5 meq/100 gram soils, it is recommend to use super dolomit around 500-750 grams/plant or 250-375 kg/ha in the soils.

Potassium is main nutrient that required to oil palm. Nitrogen is need for rapid growth of young palms. Available P and exchangable K should be high at least more than 0.5 meq/100 gram soil of exchangable K

Table 6. Soil Fertility Evaluation on Soil Mapping Units (0-20 cm and 20-40 cm)

SMU	CEC Meq/100 gr.	Base Sat. %	Organic-C %	P_20_5 ppm.	K_20 ppm.	Fertility Status
1.						
(0-20)	Low	Low	Low	Low	Medium	Low
(20-40)	Low	Low	V L	VL	Medium	Low
2.						
(0-20)	Low	VL	L	L	High	Low
(20-40)	Low	VL	VL	Low	High	Low
3.						
(0-20)	Low	Low	Low	Low	High	Low
(20-40)	VL	Low	VL	Low	Medium	Very Low
4.						
(0-20)	Low	VL	Low	Low	Low	Low
(20-40)	L	VL	VL	VL	Low	Low
5.						
(0-20)	L	VL	L	Medium	Medium	Low
(20-40)	L	VL	VL	Low	Medium	Low

M. Land Suitability

The land suitability is process to determine the degree of suitability of one area for a certain use. The land suitability of one area maybe different depends on the specific land utilization type required. Area can be considered suitable actually or potentially, when the area are consider potentially, the suitability can develop to actually after improving limiting factors.

The land suitability classification is the evaluation of an area systematically and grouping into some categories based on land characteristics (Physical environment) as a limiting factors.