SUITABILITY EVALUATION OF SOILS FOR MAIZE (*Zea mays*) AND OIL PALM (*Elaeis guinensis*) CULTIVATION IN NDEGWU, OWERRI WEST LGA, IMO STATE, NIGERIA.

***Nwaoba, O. W. and Adesemuyi, E. A.**
Department of Soil Science and Meteorology
Michael Okpara University of Agriculture, Umudike, Abia State.
*corresponding author's email: okezienwaoba@gmail.com

ABSTRACT

A study was conducted to evaluate the suitability of soils in Ndegwu, Owerri area, Imo State, Nigeria for maize and oil palm cultivation. Transects and soil angering were used to identify seven soil units. The morphological, physical and chemical properties of the soils reveal that percentage sand in all pedons were high with clay particles increasing with soil depth. The soil reaction was strongly acid to moderately acid (pH 4.70-5.80); Organic carbon (0.01- 2.10%). Total nitrogen (0.01-1.20%); CEC (4.00-33.00 cmolkg^{-1}) and exchangeable K (0.04-1.00 cmolkg^{-1}) were rated very low to high. Percentage base saturation was low to high (30.30-60.90%); Available P was low to moderate (4.50-16.50mgkg^{-1}); Exchangeable Mg was very low to high (0.01-2.00 cmolkg^{-1}). Exchangeable Na was low to moderate (0.02-cmolkg^{-1}); Available Mn ranged from 1.70-5.50mgkg^{-1} in all the pedons analyzed. Available Fe ranged from 2.33-6.80 mgkg^{-1}; Available Cu ranged from 0.4-2.15mgkg^{-1}, Available Zn ranged from 1.50-6.75mgkg^{-1} which were all above their critical limits [1.0 mgkg^{-1}(Mn), 2.0mgkg^{-1} (Fe), 0.4mgkg^{-1}(Cu) and 2.0mgkg^{-1} (Zn)]. Soil units ON-01, 02, 03 and 09 were classified as Typic Hapludult at the sub group level or Haplic Acrisol (FAO/UNESCO legend). Soil units ON-04 was classified as Oxic Dystrudent at the subgroup level or Haplic Arenosol (FAO/UNESCO) while soil units ON-06 and 08 were classified as Typic Paleudult at the sub group level (USDA) and Haplic Acrisol (FAO/UNESCO legend). Land suitability evaluation (LSE) for soil units ON-01,02,03 and 07 placed the soils as marginally suitable (S3-fc) with fertility and climate as limitations while soil unit ON-04 was classified as moderately suitable (S2-fc) also with fertility and climate as limitations. Soil units 05 and 06 were classified as currently unsuitable (N1-fc) with fertility and climate as minor and major limitations respectively for maize cultivation. For oil palm cultivation, soil units ON-01, 02, 03 and 07 were classified as marginally suitable (S3-f) with fertility as limitation, soil unit ON-04 was classified as moderately suitable (S2-f) with fertility as limitation while soil units ON-05 and 06 were classified as currently unsuitable (N1-f) with fertility as limitation. Agronomic and soil management practices such as liming, organic manuring, avoidance of bush burning and crop rotation could also make these soils highly suitable for maize and oil palm cultivation.

Keywords: Soil properties, suitability evaluation, maize and oil palm

INTRODUCTION

Sustainable use of soil is necessary for a successful agriculture to meet the increasing demand of food from the decreasing per capital land. This is because soil is an important non- renewable land resource determining the agricultural potential of a given area. (Buol*et al.,* 2003)

Soil suitability evaluation is a process of estimating the potentials of land for alternative kind of use (Anande-Kur, 1987). It involves characterizing the soils in a given area for specific land use type. Therefore, the suitability of a given piece of land is its natural ability to support a specific use. This may be major kind of land use such as rain fed agriculture, livestock production, forestry etc. (Dent and Young, 1981).

In Nigeria, a major problem of agricultural development is poor knowledge and appraisal of suitability of parcels of land for agricultural production. The result is poor farm management practices, low yield and an unnecessary high cost of production (Ibanga, 2001). Land evaluation using scientific procedure is essential to assess the potentials and constraints of a given land parcel for agricultural purposes (Rossiter, 1996). The knowledge of soil limitations arising from land evaluation reports aim at ameliorating such limitations before or during cropping period. Therefore, soil as a medium for cultivation needs to be assessed (surveyed/characterized) scientifically. The performance assessment is based on matching qualities of different land units in specific area with the requirements of actual or potential land use types. This assessment results in classification of lands as to their suitability to produce specific crops or combination of crops (Ezeaku, 2011).

Maize (*Zea may L.*) is the most important cereal crop in sub-Saharan Africa (SSA). Along with rice and wheat, maize is one of the three most important cereal crops in the world. In Nigeria, maize is a staple food of great socio-economic importance. The demand for maize sometimes outstrips supply as a result of various domestic uses (Akande, 1994). Oil palm (*Elaeis guinensis*) is an important economic tree which originated in tropical West Africa. It is a source of food, oil, palm wine, palm kernel cake for feeding livestock and palm oil for making soap, pomade, margarine, candles etc. (Adeniji *et al.,* 1991). The management of soil is the more compounded by the use of plantation sites for arable cultivation, thus resulting in poor yield of major food crops-yam, cassava, maize etc. (Ohajianya, 2006).

Ndegwu is an agrarian community. Its dwellers are both commercial and subsistence farmers of both small and large-scale production of several staple crops such as cassava, yam, maize and tree crops like oil palm among others. The soils have been under intensive cropping by inhabitants of the community. Due to lack of guidance, many farmers cultivate crops on soils that may not be suitable for their cultivation.

Thus, the main objectives of this study were to:

1. characterize and classify the soils using the USDA and World Reference Base soil classification systems (Soil Survey Staff, 2010) and
2. evaluate the suitability of these soils for maize and oil palm cultivation**.**

MATERIALS AND METHODS

Description of study area

The study was conducted in Ndegwu, Owerri West local government area of Imo state, Nigeria. It lies between latitude $4^0 45^I$N and 7^0 15^IN and longitude $6^0 50^I$E and $7^0 25^1$E, with elevation ranging between 80 – 100m above sea level (Fig. 1). The mean annual rainfall ranges between 1900mm and 2200mm with the southern areas receiving a little more than the northern areas. Generally, the entire state is under an udic moisture regime. The mean annual temperature range is between 26^0C and 28^0C (NRCRI, 2011). On annual basis, the relative humidity varies with the seasons which itself is a function of the prevailing major air mass. High ranges of 80% to 90% at 10am Nigerian time occur during the rainy season when the south Westerly is prevalent. The dry season range under the dry North easterly wind is between 60% and 80% at the same 10am Nigerian Time. Daily variations of relative humidity depend and fluctuate over a wide range (FDALR, 1995). Average monthly evapotranspiration also remain low during the rainy season with an average of

2.5 to 3.5mm/day during the dry season (FDALR, 1995).

The parent material is coastal plain sand. It is of the Pleistocene- Oligocene era and consists of unconsolidated yellow and white sand materials which are sometimes cross bedded with clays, sand clays and sometimes pebbles (NRCRI, 2011).

The vegetation is tropical rainforest. The original vegetation however had been destroyed to a considerable extent through human activities. The prevailing plants available in the area are oil palm (*Elaeis guinensis*), African oil beans (*Pentaclatra spp*.) and a large herbaceous plants and grasses such as *Chromolaena odorata, Pennisetum spp, Imperata cylindrical,* etc.

The general land use is shifting cultivation or bush fallow system. Presently due to population pressure and increased demand on the land, shorter fallow periods are most common (NRCRI, 2011). Land productivity in terms of crop yield has also continued to decline under this system due to declining soil fertility (NRCRI, 2011).

Major crops under this traditional farming method include yams (*Discorea spp*), cassava (*Manihot esculenta*), maize (*Zea mays*), cocoyam (*Colocasia esculenta*) and a variety of vegetable crops -Fluted pumpkin (*Telferia occidentalis*), Okro (*Abelmoschus* esculenta) (NRCRI, 2011).

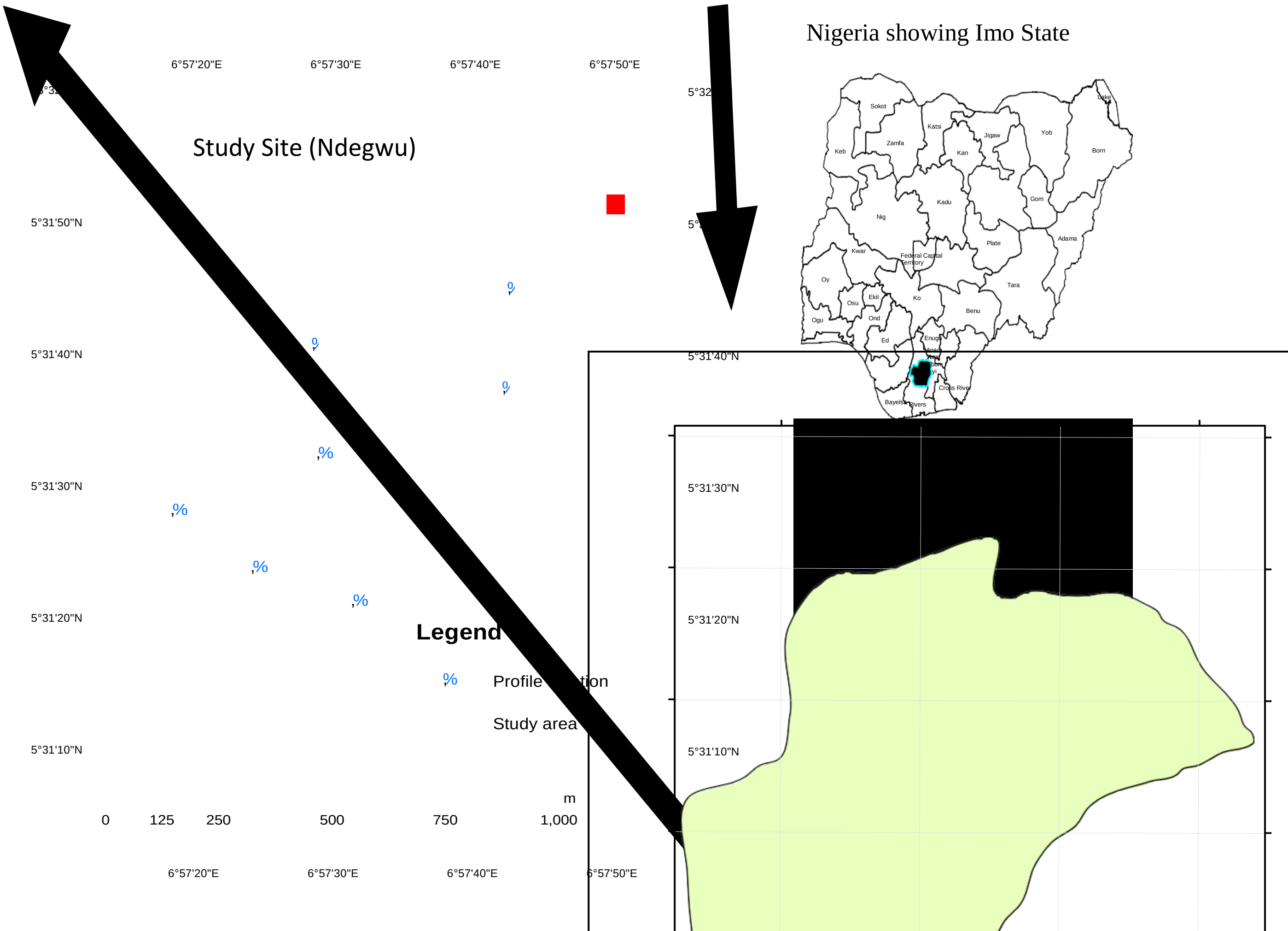

Fig. 1: Map of Nigeria showing Imo State, the study area (Owerri We[illegible]u)
Figure 1: Map of the Study area showing soil profile locations

Field work
A reconnaissance visit of the area was conducted. Soil augering was done to a depth of 120cm where possible or to impervious layer. All the samples collected from the auger holes were described morphologically on the field in terms of soil texture by feel and consistency, soil colour, presence or absence of mottles, mottle colour, stoniness, presence or absence of concretions, root content etc. Soils from the auger points were grouped into mapping units based on the similarities of the above mentioned following morphological properties. Three mapping units were identified and ten profile pits measuring 2m x 1.5m x 2m were dug. Soils of the pedogenic horizon were described according to (FAO,2011). Soil samples were collected from the bottom to the top for laboratory analysis.
Laboratory Analysis
The soil samples collected were air dried, crushed and pass through a 2mm sieve. The resulting soil samples were analyzed for physical and chemical properties as follows: Particle size distribution was determined by hydrometer method (Gee and Bauder, 1986). Tota[illegible] was determined by the micro kjedahl wet oxidation method [illegible]ner, 1996). Organic carbon was determined according to Nelson and Sommers (1982). Exchangeable bases were extracted with neutral 1N ammonium acetate (NH_4OAc) solution; Ca and Mg were determined by EDTA titration while K and Na were determined using Flame photometry. Exchangeable acidity was determined by KCl extraction, following the procedure of Mclean (1965) cation exchange capacity (CEC) was measured using ammonium acetate leaching at pH 7.0 (Roades, 1982)
The base saturation was calculated by multiplying the quotient obtained after dividing TEB and CEC by 100. Soil pH in H_20 and KCL were determined using pH meter at 1:1 and 1:2.5 soil ratios according to Thomas, (1996). Available phosphorus was determined by Bray P-ll method (Nelson and Sommers, 1982) modified. Electrical conductivity was determined in a 1:2.5 soil/water ratio using the conductivity meter (Fox, 1982). Bulk density was measured by core method (Grossman and Reinsch, 2002) and saturated

hydraulic conductivity (k_{sat}) was determined using the constant head parameter method and obtained using the equation of the form (Klute and Dirksen, 1986).
The soils were classified according to the USDA soil classification (Soil Survey Staff, 2010) with side by side correlation with world reference base (WRB) soil map of the world legend.

RESULTS AND DISCUSSION

Morphological and physical properties

The topography of all the soils is nearly level plains with slope range of 0 – 2%. The soils are deep and well drained; depth to water table is below 180cm. Results of the particle size analysis show that sand particles are the dominant size particles at the surface horizon (53 – 90%) followed by clay with values (7 – 45%) and silt fraction with values (1-7%). There was decrease in sand with all the soil depths while the clay particles increase with the soil depth. There exists an irregular pattern of silt distribution in the soils which may be as a result of lithology or the parent material or other anthropogenic influences and the high sand particles at the uppermost horizon could be attributed to deposition by flowing water (Akamigbo and Asadu, 1986). Soil textures of mapping units ON-01, 02, 03 and 09 ranged from loamy sand at the surface and sandy loam at the sub surface horizons. The bulk density and the saturated hydraulic conductivities of ON-01, 02, 03 and 09 ranged from loamy sand to sand clay at the surface and sandy clay loam to sandy clay to the sub surface horizons while soil unit ON-04 ranges from loamy sand to sandy loam to the sub surface horizons. The bulk density and the saturated hydraulic conductivities of mapping unitsN-01, 02, 03 and 09 ranged from 1.05-
1.47 g/cm^3 and 0.09-9.28 cm/hr respectively. Soil unit 04 ranged from 1.06-1.25 g/cm^3 and
34.20 - 40.64 cm/hr while soil units 05 and 06 ranged from 1.24-1.38g/cm3 and 0.09-50.33 cm/hr for bulk density and saturated hydraulic conductivity respectively. The bulk density increased with the soil depth while the saturated hydraulic conductivity decreased with the soil depth.

Table 1: Summary of morphological properties of the soil units

Pedon	Horizon	Depth (cm)	Texture	Slope %	Colour (Munsel) Moist	Sand	Silt %	Clay	Structure	Consistence (moist)	Horizon Boundary
1	AP	0-13	LS	2	DGB(10YR3/2)	90	3	7	Fine Crumb	VFr	Abrupt Wavy
	AB	13-28	SL		DB(7.5YR3/4)	81	3	16	Fine Sbk	Fr	Gradual smooth
	Btl	28-80	SCL		RB(7.5YR3/4)	70	4	26	Fine Sbk	Fm	Clear smooth
	Bt2	80-126	SCL		YR(5YR5/4)	64	4	32	Strong Sbk	m	Clear smooth
	BC	126-180	SC		R(2.5YR4/8)	58	3	39	Strong Sbk	Fm	
2	AP	0-13	LS	1	DB(10YR3/3)	86	7	7	Weak granular	VFR	Gradual smooth
	AB	13-32	SL		DYB(10YR4/4)	78	4	18	V.fineSbk	Fr	Gradual smooth
	Btl	32-70	SCL		SB(7.5YR)	73	3	24	M.fineSbk	Fm	Clear smooth
	Bt2	70-127	SC		RB (5YR5/4)	64	2	34	Msbk	Fm	Clear smooth
	BC	127-180	SC		YR(5YRS5/8)	54	2	44	Coarse Sbk	Fm	
3	AP	0-13	LS	3	DB(10YR3/2)	86	5	9	Fine crumb	Fr	Abrupt Wavy
	AB	13-29	SL		DYB(10YR4/4)	81	J	16	Weak Fine Sbk	Fr	Gradual smooth
	Btl	29-63	SCL		RB(5YR5/4)	67	2	31	Msbk	Fm	Clear smooth
	Bt2	63-128	SCL		YR(5YR5/8)	64	1	35	Msbk	Fm	Clear smooth
	BC	128-180	SC		RY(5YR6/6)	53	2	45	Coarse Sbk	Fm	
4											
	AP	0-14	LS	3	DB(10YR3/3)	88	3	9	Weak crumb	Vfr	Gradual smooth
	AB	14-33	LS		DB(7.5YR3/4)	84	5	11	Weak fine Sbk	Fr	Clear smooth
	BA	33-78	SL		SB(7.5YR4/6)	80	3	17	Msbk	Fr	Gradual smooth
	B	78-126	SL		YR(7YR4/6)	82	2	16	Msbk	Fr	Clear and smooth
	BC	126-180	SL		Weak crumb	78	3	19	Msbk	Fr	

Table 1: Summary of morphological properties of the soil units contd.

Pedon	Horizon	Depth (cm)	Texture	Slope %	Colour (Munsel) Moist	Sand	Silt %	Clay	Structure	Consistence (moist)	Horizon Boundary
05	AP	0-12	LS	2	DB (10YR3/3)	86	3	10	Fine crumb	Vfr	Abrupt smooth
	AB	12-30	SL		DB (7.5YR3/4)	81	4	16	Week fine SBK	Fr	Clear smooth
	Bt1	30-72	SCL		RB (5YR5/8)	73	4	23	MSBK	Fr	Clear smooth
	Bt2	72-217	SCL		YR (5YR5/8)	60	3	27	MdSBK	Fr	Gradual
	BC	127-180	SC		YR (5YR4/8)	58	2	40	MdSBK	Fr	
06	AP	0-13	LS		DG (10YR3/2)	87	3	10	Fine granular	VFr	Abrupt smooth
	AB	13-31	SL		DB (7.5YR4/4)	80	4	16	Fine Msbk	Fr	Gradual
	Bt1	31-69	SCL		RB (5YR5/4)	73	4	23	Msbk	Fr	Clear smooth
	Bt2	69-124	SSC		BY (5YR45/8)	60	3	27	Msbk	Fr	Gradual
	BC	124-180	SC		RY (5YR4/8)	58	2	40	Coarse Msbk	Fr	
07	AP	0-13	LS		DB (10YR3/2)	90	2	8	Fine crumb	VFr	Abrupt smooth
	AB	13-32	SL	3	DB (7.5YR34/6)	80	4	16	Msbk	Fr	Clear smooth
	Bt1	32-78	SL		SB (7.5YR4/6)	74	3	23	Msbk	Fr	Gradual smooth
	Bt2	78-129	SCL		YR (54Yr4/6)	62	6	32	Msbk	Fr	Clear smooth
	BC	129-180	SCL		YR (5Yr5/8)	60	4	36	Coarse Abk	Fr	

Note: DGB- Dark greyish brown, DB- Dark brown, RB- Reddish brown, YR- Yellowish red, R- red, DYB- Dark yellowish brown, RY- Reddish yellow, SB- Strong black, DG-Dark greyish, Fr- Friable, VFr- Very friable, LS- Loamy sand, SL- Sandy loam, SCL-Sandy clay loam, abk- Angular blocky, sbk- sub angular blocky, msbk- medium sub angular blocky.

Table 2: Physical Properties of the Soil Units

profile ID/ Location	Depth (cm)	Textural Class	Bulk Density	Saturated hydraulic conductivity
ON – 01	0-25	SL	1.05	16.34
Nwalaubi, Ndegwu	25-50	SCL	1.05	0.09
	50-75	SCL	1.06	0.05
	75-100	SC	1.09	0.01
ON-04	0-25	LS	1.05	40.64
Nwaowugwu,	25-50	SL	1.06	35.10
Ndegwu	50-75	SL	1.20	34.20
	75-100	SL	1.29	32.10
ON-05	0-25	SL	1.24	50.33
Ogwugwu, Ulcwu,	25-50	SCL	1.35	0.09
Ndegwu	50-75	SCL	1.36	0.08
	75-100	SCL	1.38	0.06
ON-06	0-25	SL	1.14	8.52
Ogwugwu, Ukwu,	25-50	SCL	1.40	0.54
Ndegwu	50-75	SCL	1.45	0.65
	75-100	SCL	1.47	0.08
ON-07	0-25	SL	1.15	9.28
Ogwugwu,	25-50	SCL	1.28	0.14
UkwuNdegwu	50-75	SCL	1.38	0.09
	75-100	SC	1.49	0.08

Chemical Properties

The chemical properties of the soils are presented in Table 3. The overall result indicates that the soils are very strongly acid (pH 4.70-5-5.80). The results confirm earlier study by Chukwu (2007) that soils of south eastern Nigeria derived from Shale are acidic. Organic carbon content of the soils is generally low in all the soil units and ranged from (0.09-0.9%). The decrease in organic carbon with depth of all the soils indicates continuous decomposition of organic materials and sediments which may have slowed decomposition.

Also, based on soil fertility ratings of south eastern Nigeria (Enwezor *et al*, 1990), the area suffers nutrient deficiencies particularly N and K. Total N is low (<0.15%). Similarly, exchangeable K is also low (<0.2 cmolkg^{-1}). In all the soils, exchangeable cations are low for calcium (0.22-6.3 cmolkg^{-1}), very low for magnesium (0.06-2.00) low for sodium (0.06-0.2). The low availability of the exchangeable cations could be as a result of low pH. Available phosphorus is low (4.25-15.00 mgkg^{-1}). Cation Exchange capacity is low to-moderate (4.00-
15.00 mg/kg) and percentage base saturation is low to moderate (06.30- 50.00%). According to Chukwu and Okonkwo (2015), the low overall soil fertility could be associated with repeated cycles of erosion history of landscape in the humid and arid climates of Africa in the tertiary geological period. Consequently, most of their basic nutrients might have been leached before decomposition.

Available micronutrients indicated medium to high for Fe (1.65-6.80mgkg^{-1}), Zn (1.50- 7.5mgkg^{-1}), Cu (0.13-2.15mgkg^{-1}) and Mn (0.20-5.55mgkg^{-1}) Table 3. The medium to high levels of micronutrients in these soils might be as a result of low pH status of the soils. Consequently, these soils will require liming to avert micronutrient toxicities.

Table 3: Chemical properties of soil units

		Depth	pH		EC	Organic carbon	Total	Exchangeable Acidity (cmol/kg)			mg/kg	Exchangeable Cations (cmol/kg)						Available Micro Nutrients cmol/kg			
Pedons	**Horizon**	**(cm)**	**H20**	**KCL**	ms/cm	**%**	**N%**	**TEA**	**H^+**	**AL^{3+}**	**Avail P**	**Ca**	**Mg**	**K**	**Na**	**CEC**	**BS**	**Cu**	Zn	Mn	Fe
ON-Ol	AP	0-13	5.4	4.6	0.10	0.98	0.08	2.10	1.90	0.20	13.00	0.22	0.06	0.13	0.08	5.00	9.80	2.50	3.50	4.40	1.75
	AB	13-28	5.3	4.1	0.8	0.81	0.04	1.80	1.50	0.20	10.20	1.09	0.31	0.06	0.10	9.00	17.30	1.50	4.20	5.20	2.15
	Btl	28-30	5.2	4.0	0.7	0.62	0.03	1.68	1.30	0.38	8.70	0.28	0.02	0.13	0.13	5.00	11.20	1.80	2.50	4.70	1.60
	Bt2	80-126	5.1	3.8	0.6	0.51	0.02	.50	1.85	0.65	7.60	0.22	0.08	0.13	0.11	8.00	5.80	2.20	3.40	3.80	0.90
	BC	126-.180	5.0	3.7	0.32	0.31	0.01	1.20	0.30	0.30	6.75	0.31	0.01	0.13	0.15	4.00	15.00	2.00	1.70	5.10	0.80
ON-02	AP	0-13	5.3	4.1	0.19	0.20	1.06	0.70	0.61	0.09	14.00	2.10	0.70	0.40	0.06	7.50	40.40	3.40	2.20	4.60	0.30
	AB	13-32	5.2	4.0	0.12	0.95	0.05	0.09	0.72	0.08	12.00	1.70	1.01	0.46	0.02	9.30	20.00	4.70	2.10	2.40	0.20
	Btl	32-70	50	3.9	0.10	0.75	0.25	0.85	0.75	0.10	10.50	2.50	1.50	0.91	0.18	10.40	50.20	4.25	1.30	2.05	0.13
	Bt2	70-127	4.9	3.8	0.10	0.09	0.01	0.95	0.90	0.05	7.30	2.63	1.20	0.72	0.11	12.50	30.30	3.80	2.15	3.40	0.68
	BC	127-180	4.7	3.6	0.80	0.08	0.05	0.90	0.85	0.05	6.75	2.15	2.00	1.00	0.20	15.00	36.30	3.80	3.14	5.14	0.75
ON-03	AP	0-13	5.8	4.9	1.63	0.98	0.08	0.74	0.60	0.14	8.15	2.20	2.00	0.17	0.40	15.90	29.40	3.80	2.20	4.80	0.90
	AB	13-29	5.6	4.7	0.08	0.86	0.07	0.84	0.58	0.07	7.20	1.20	0.80	0.12	0.15	11.20	20.00	3.90	1.70	5.40	0.70
	Btl	29-63	5.3	4.5	0.00	0.54	0.06	0.68	0.32	0.17	6.10	0.08	0.40	0.17	0.20	9.60	16.20	3.10	1.30	3.65	1.10
	Bt2	63-128	5.0	3.0	0.06	0.27	0.04	0.70	0.25	0.05	5.20	2.40	2.00	0.09	0.14	7.70	66.30	3.85	2.40	2.33	0.88
	BC	128-180	4.9	3.7	0.32	0.26	0.02	0.55	0.03	0.01	4.25	2.60	1.20	0.11	0.17	5.50	68.90	4.50	2.34	3.32	0.95
ON-04	AP	0-14	5.5	4.6	0.08	0.98	0.08	0.74	0.61	0.14	15.70	1.00	0.34	0.20	0.12	4.30	39.80	3.70	1.10	2.10	0.66
	AB	24-33	5.4	4.4	0.11	0.86	0.06	0.65	0.72	0.10	12.30	0.20	0.34	0.20	0.13	2.60	29.00	3.10	0.80	3.15	0.75
	Btl	33-78	5.2	4.3	0.06	0.62	0.02	0.49	0.75	0.10	11.00	1.40	0.10	0.08	0.04	8.80	09.00	3.80	1.60	2.15	1.84
	Bt2	73-126	5.1	3.9	0.07	0.54	0.01	0.40	0.90	0.08	7.80	0.40	0.18	0.06	0.03	6.50	10.00	4.00	1.80	1.65	0.95
	BC	126-180	5.0	3.8	0.05	0.45	0.01	0.30	0.85	0.13	5.15	0.90	0.12	0.17	0.12	8.60	13.00	4.30	1.40	2.54	0.88
ON-05	AP	0-13	5.4	4.9	0.08	0.20	0.11	1.42	1.34	0.08	15.50	1.90	0.60	0.10	0.10	6.00	45.00	3.80	1.15	4.90	0.50
	AB	13-28	5.2	4.8	0.07	0.95	0.05	1.15	1.00	0.15	7.40	0.95	0.35	0.05	0.13	6.00	25.00	4.15	1.60	5.80	0.75
	Btl	28-65	5.1	4.3	0.06	0.70	0.03	0.96	0.89	0.05	11.75	0.60	0.50	0.04	0.08	6.00	20.00	3.89	1.80	6.70	0.90
	Bt2	65-125	5.0	3.9	0.05	0.43	0.02	0.80	0.70	0.10	9.58	1.45	0.15	0.17	0.07	7.50	25.00	4.50	2.10	44.55	0.84
	BC	125-180	4.9	3.8	0.04	0.24	0.02	0.70	0.05	0.36	6.89	0.50	0.30	0.14	0.08	3.00	34.00	5.10	1.35	4.50	0.77
ON-06	AP	0-13	5.3	4.7	0.12	1.00	0.08	1.85	1.75	0.10	13.10	1.20	0.80	0.23	0.06	8.00	27.00	4.90	2.50	4.90	0.60
	AB	13-31	5.2	4.6	0.10	0.95	0.06	1.20	1.60	0.60	9.60	1.10	0.40	0.18	0.04	5.70	30.00	2.80	5.90	5.60	0.90
	Bt1	31-69	5.1	4.3	0.10	0.84	0.04	1.15	1.00	0.15	10.20	1.10	0.40	0.19	0.11	5.40	32.00	3.90	4.20	6.55	1.00

	Bt2	69-124	5.0	3.0	0.08	0.54	0.03	0.98	0.85	0.13	6.60	0.20	0.13	0.04	0.70	3.10	21.00	4.67	5.00	4.80	0.70
	BC	124-180	4.9	3.9	0.07	0.43	0.03	0.80	0.76	0.04	7.85	0.50	0.70	0.13	0.40	2.60	53.00	4.40	3.70	4.80	0.50
ON-07	AP	0-13	5.3	5.0	1.02	2.10	0.09	1.80	1.20	0.60	16.50	1.40	0.80	0.26	0.13	7.00	37.00	4.50	2.50	6.50	1.00
	AB	13-32	5.4	4.8	0.90	1.50	0.07	1.00	0.90	0.10	12.60	1.32	1.88	0.42	0.07	8.20	40.00	5.60	3.47	5.40	0.75
	Bt1	32-78	5.2	4.3	0.80	0.95	0.06	0.95	0.85	0.10	10.70	1.75	1.84	0.42	0.06	10.00	41.00	7.45	4.70	3.50	0.59
	Bt2	78-129	5.1	4.2	0.70	0.80	0.02	0.86	0.76	0.10	8.60	1.63	1.73	0.29	0.07	12.40	30.30	4.54	5.55	5.10	0.60
	BC	129-180	5.4	4.0	0.60	0.01	0.01	0.75	0.69	0.06	7.50	2.50	1.70	0.43	0.05	15.50	30.30	3.12	2.60	4.50	0.58

Taxonomic Classification of the Soil Units

The taxonomic classification of the soil units is shown in table 4. Map showing taxonomic classification of the soil units is shown in figure 2.

Soil units ON-01, 02, 03 and 07 were classified as Ultisol or Acrisol because of the argillic or kandic B horizon with low base saturation. Udic soil moisture regime that is freely and well drained is classified as Udults. It was further classified as Hapludult at great group level because of the clay distribution in which the clay content increases with increasing depth and Typic Hapludults because they are freely and moderately deep to hard rock and also have an ochric epipedon that is not both thick and sandy.

Soil unit ON-04 is classified as Entisols because it shows no evidence of pedogenic horizons. The soil unit has an udic moisture regime hence classified as udent. The soil unit was further classified as Dystrudent at great group level because it does not have free carbonates within the soils and has a base saturation of less than 60 percent in all sub horizons between depths of 25 and 75cm between the soil surface hence was further classified as Oxic Dystrudent. Soil units ON- 05 and 06 were classified as Ultisols because they have thick argillic horizon, low base saturation and low CEC. Ultisols with udic soil moisture regime are classified as Udults. They are also classified as Paleudults because they have a clay distribution in which the percentage clay does not decrease from its maximum amount more than 20 percent within 150cm of the soil surface.

TABLE 4: Taxonomic Classification of the Soil Units

SOIL UNIT	USDA SOIL TAXONOMY	FAO/UNESCO
ON - 01	Typic Hapludult	Haplic Acrisol
ON - 02	Tvpic Hapludult	Haplic Acrisol
ON - 03	Typic Hapludult	Haplic Acrisol
ON - 04	Oxic Dystrudent	Haplic Arenosol
ON - 05	Typic Paleudult	Haplic Acrisol
ON - 06	Typic Paleudult	Haplic Acrisol
ON – 07	Typic Hapludult	Haplic Acrisol

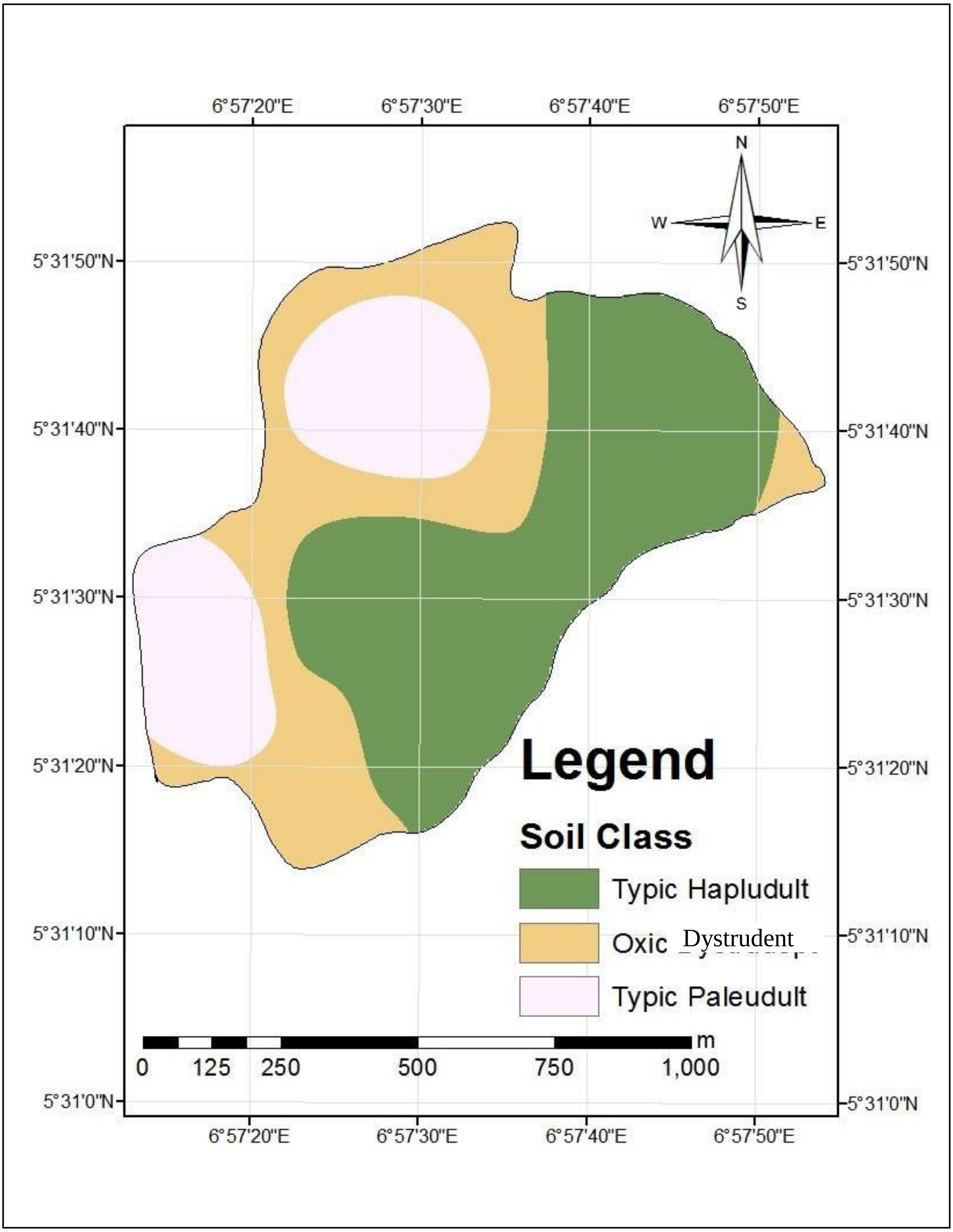

Figure 2: Map showing Taxonomic Classification of Soil Units

Soil Suitability Evaluation

Land characteristics of the study area (Table 5) were matched with the agronomic requirements of maize and oil palm (Tables 6 and 7) to obtain suitability class scores of maize and oil palm in the study area (Tables 8 and 9).

Table 5: Land characteristics / quality of the study area

Soil Unit (ON)	**(01,02,03,07)**	**(04)**	**(05,06)**
Land Characteristics	Typic Hapludults	Oxic Dystrudents	Typic Paleudults
Rainfall (mm)	1900-2200	1900-2200	1900.2200
Temperature (^{0}C)	27-28	27-28	27-28
Relative humidity (%)	72	72	72
pH (H_{20})	5.18	5.24	5.11
pH (KCl)	4.14	4.20	4.32
E.C	0.27	0.08	0.077
Organic carbon (%)	0.77	0.70	0.73
Total N (%)	0.19	0.09	0.13
Avail P	9.05	10.99	9.84
Exch.Ca^{2+} (cmol/kg)	1.58	0.78	0.95
Exch.Mg^{2+} (cmol/kg)	1.08	0.61	0.41
Exch.K^{2+} (cmol/kg)	0.39	0.16	0.13
Exch.Na^{2+} (cmol/kg)	1.77	0.10	022
Total Exch. Acidity	1.10	0.71	1.11
H+	0.91	0.59	1.42
$A1^{3+}$	0.16	0.11	0.14
BS	30.71	20.00	29.30
Avail. Mn^{2+}	2.77	1.34	2.90
Fe^{2+}	4.54	2.39	5.32
Zn+	4.24	3.78	4.21
CEC	9.33	12.16	5.33
Ksat	3.36	30.41	10.71
Txture	SCL	SCL	SCL
Soil drainage	Well drained	Well drained	Well drained
Bulk density	0.51	0.92	1.04
Topography	0.2%	2-3%	2-3%
Soil Depth	126	125	130

Table 6: Land and soil Requirements for suitability rating of maize (*Zea mays*)

Land/Soil Characteristics	Rate	100-95	84-40	39-20	19-0
	Class	S1	S2	S3	N1
Climatic (c)					
Mean Annual Rainfall	mm	850-1250	600-750	500-600	-
			1600-1800	>1800	-
Mean Annual Max. Temp.	^{o}C	22-26	18-16	26-30	-
			32+		
Relative Humidity	%	50-80	<80	-	-
Length of rainy season	days	150-220	110-130	90-110	-
Topography (t)					
Slope	%	0-2	4-8	8-16	>30-50
		0-4	8-16	16-30	>30
		F0	F1	Aeric	Poor
Wetness (w)		Good	Poor	Poor	Drainable
Flooding					
Drainage	Class				
Physical properties (s)					
Texture/structure	Class	CL,C	LCS	CS,S	S
Coarse fragments (0-50cm)	%	<3	15-35	35-55	-
Soil fertility (f)					
CEC	(cmolkg^{-1} clay)	>24	<16(-)	<16(+)	-
Base Saturation	%	>50	20-35	<20	-
OC (0-15cm)	%	>2	0.8-1.2	<0.8	-
pH	Water	5.5-7.0	5.0-5.5	4.0-5.0	-
Avail. P.	Mgkg-1	>22	7-13	3-7	<3
Total Nitrogen (%)	%	>0.15	0.08-0.15	0.04-0.08	<0.08
Extractable K	cmolkg^{-1}	>0.50	0.20-0.50	0.10-0.20	<0.10

Key: F0 – No Flooding, F1- Seasonal Flooding, MR-Flooding Rare; C-Clay, CL-Clay Loam, LS-Loamy Sand, SL-Sandy Loam, LCS –Loamy Clay Sand, CS-Clay Sand, S-Sand, S1- Highly suitable, S2-Moderately suitable, S3-Marginally suitable, N1- Currently not suitable
Source: Adesemuyi, 2014 (modified)

Table 7: land requirements for the production of Oil palm (*Elaeis guinensis*)

		Land Suitability Class		
Land requirements/ Land characteristics	S1	S2	S3	N1
Climate (c):				
Annual rainfall (mm)	1700-2500	1450-1700 2500-3500	1250-1450 3500-4000	1000-1250
Length of dry season (Months)	<2	2-3	3-4	>4
Mean annual temp. (°C)	25-28	22-25 28-32	20-22 32-35	>35
Topography (t):				
Slope (%)	<8	8-16	16-30	>30
Erosion hazard (eh)	Very low	Low-moderate	Severe	Very Severe
Wetness (w)*:				
Flooding	F0	F1	F2	>F2
Drainage	Moderate	Moderate-Poor	Poor-mod. Rapid	Very poor-Rapid
Soil Physical Characteristics (s):				
Texture (surface)	Fine-medium	Medium-slightly Coarse	Coarse	Very coarse
Surface stoniness (Vol. %) 0-10cm	<5	5-15	15-40	40-45
Rock out crops (%)	<5	5-15	15-25	5-30
Soil depth (cm)	>100	75-100	50-75	50-45
Coarse material (%)	<15	15-35	35-55	>55
Fertility (f):				
Cation exchange capacity (cmol-kg-1) clay	>16	12-16	8-12	5-8
Base saturation (%)	>20	15-19	10-14	<10
pH H_20	5-6.5	4.2-5 6.5-7	<4.2 >7.0	<4
Organic carbon (%), 0-15cm	>0.8	0.5-0.8	0.3-0.5	<0.3
Alkalinity (ESP)	-	-	-	-

Modified from: Djaendin *et al*., (2003)

Table 8: Suitability class score of the soil units for maize cultivation

Soil units	ON 01	ON 02	ON 03	ON 04	ON 05	ON 06	ON 07
Rainfall (mm)	S3	S3	S3	S3	S3	S3	S3
Temp (^{0}C)	S3	S3	S3	S3	S3	S3	S3
Topography Slope	S1	S1	S1	S1	S1	S1	S1
Drainage	S1	S1	S1	S1	S1	S1	S1
Texture	S2	S2	S2	S2	S2	S2	S2
Fertility CEC	S3	S3	S3	S3	S3	S3	S3
B.S (%)	S2	S2	S2	S2	S2	S2	S2
O.M	S1	S1	S1	S1	S1	S1	S1
pH (H_{20})	S2	S2	S2	S2	S2	S2	S2
Avail P	S2	S2	S2	S2	S2	S2	S2
Total N	S1	S1	S1	S2	S2	S2	S1
Exch. K^+	S2	S2	S2	S3	S3	S3	S2
Aggregate suitability score	S3-fc	S3-fc	S3-fc	S3-fc	S3-fc	S3-fc	S3-fc

Table 9: Suitability class score of the soil units for oil palm cultivation

Soil units	ON 01	ON 02	ON 03	ON 04	ON 05	ON 06	ON 07
Rainfall (mm)	S2	S2	S2	S2	S2	S2	S2
Temp (^{0}C)	S1	S1	S1	S1	S1	S1	S1
Slope (%)	S1	S1	S1	S2	S2	S2	S1
Soil Drainage	S1	S1	S1	S1	S1	S1	S1
Texture	S1	S1	S1	S2	S2	S2	S1
Soil depth (cm)		S1	S1	S1	S1	S1	S1
Fertility CEC	S3	S3	S3	S2	N1	N1	S3
B.S (%)	S1	S1	S1	S1	S1	S1	S1
pH (H_{20})	S1	S1	S1	S1	S1	S1	S1
Organic carbon (%)	S2	S2	S2	S2	S2	S2	S2
Aggregate suitability score	S3-f	S3-f	S3-f	S2-f	N1-f	N1-f	S3-f

Maize

For maize, all the soil units were marginally suitable S3-fc with fertility (Base saturation, CEC, Available P and Exch.K) and climate (temperature and rainfall) as major and minor limitations.

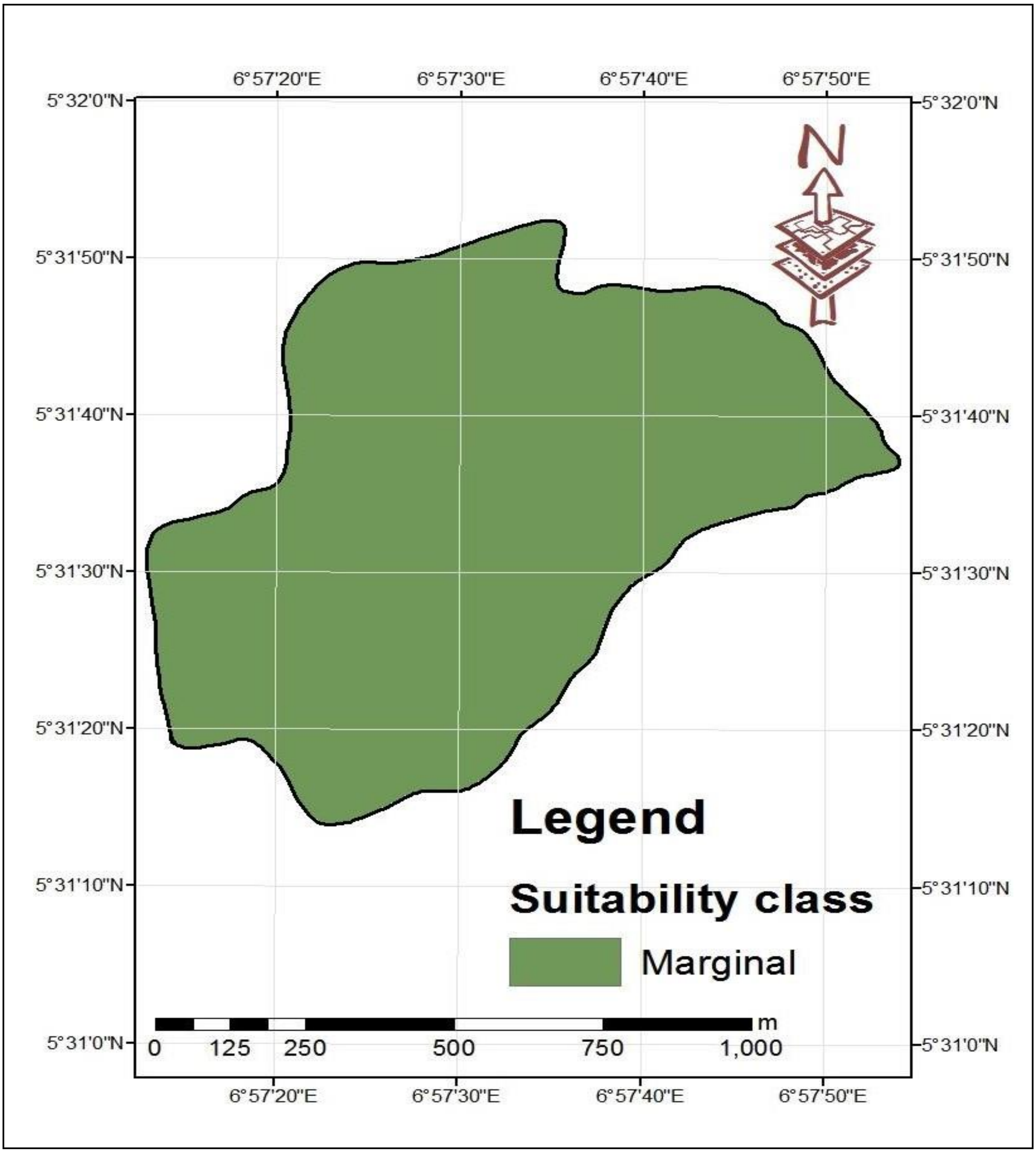

Fig 3: Map of soil suitability for maize in the study area

Oil palm

For oil palm cultivation, 01, 02, 03 and 07 were marginally suitable S3-f with fertility (CEC and organic carbon), soil unit 04 was classified as moderately suitable S2-f with fertility (CEC and Organic carbon) as minor limitation while soil units 05 and 06 were classified as currently unsuitable N1-f with fertility (CEC) as major limitation.

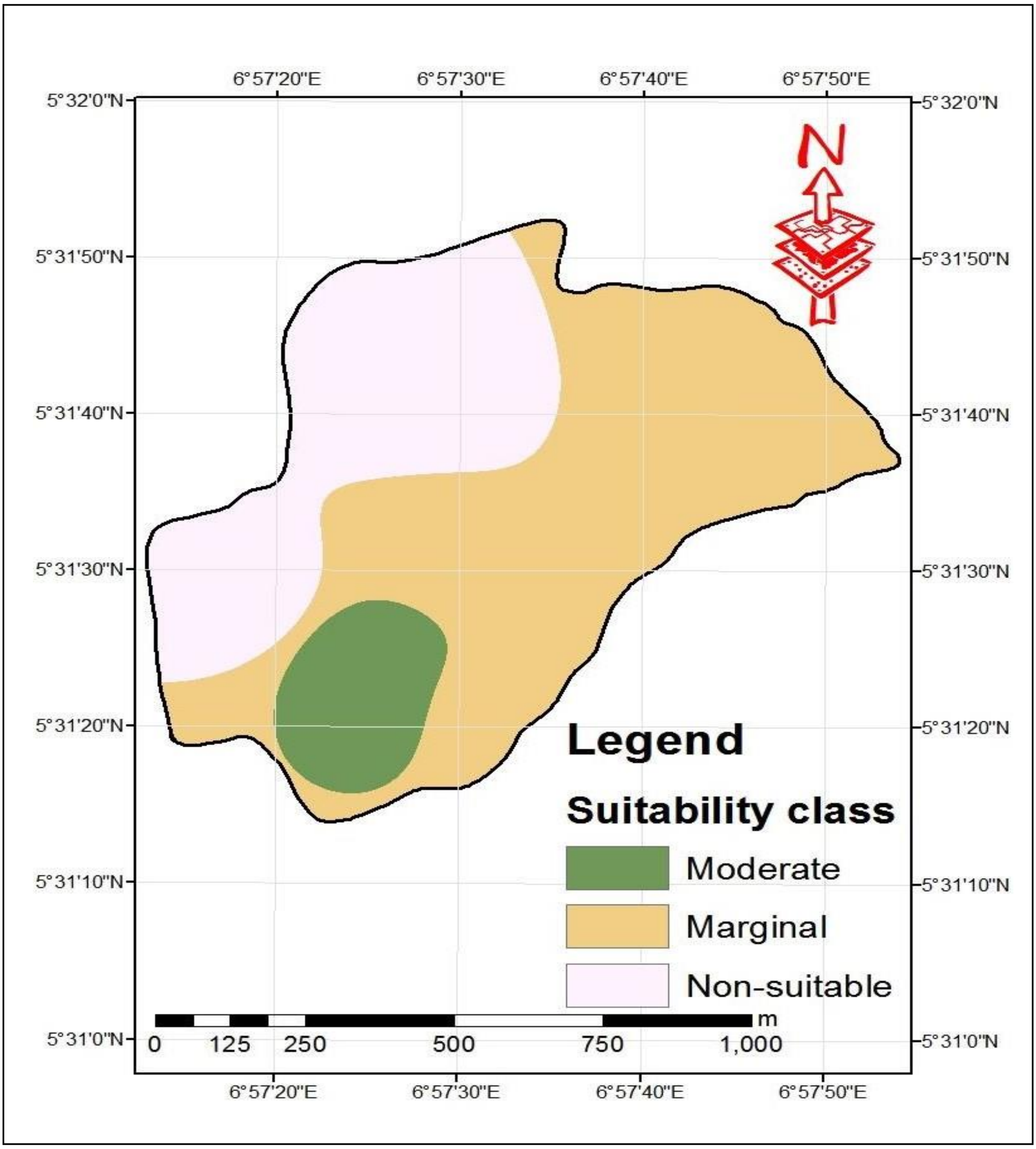

Fig 4: Map of soil suitability for oil palm in the study area

CONCLUSION AND RECOMMENDATION

The dominant class of the soils was sandy clay loam. The soils were classified as Typic Hapludults (USDA) or Haplic Acrisol (FAO/UNESCO legend), Oxic Dystrudent (USDA) or Haplic Arenosol (FAO/UNESCO Legend) and Typic Paleudult (USDA) or Haplic Acrisol for soil units (on – 01, 02, 03, 07), (on -04) and (on -05 and 06) respectively. The soils were strongly acidic and can be controlled by liming. Fertility (low CEC, Organic carbon, total nitrogen and base saturation) was the major limitation to the soils suitability for maize cultivation and for oil palm cultivation. As such maize and oil palm can also be cultivated at any of the soil units after improving the fertility. Proper land preparation, avoidance of bush burning, practicing crop rotation, cultivation of leguminous crops to ensure increase in total nitrogen and application of organic fertilizer could also make these soils highly suitable for maize and oil palm cultivation in the study area.

REFERENCES

Adeniji, M.O., Udeogalanya, A.C, Okeke, G.C, Abdullahi, Y. Iheukwumere, C.A. (1991). Countdown to Senior Secondary Certificate Examination: Agricultural Science. Ibadan, Erans Brothers (Nigeria Publishers) Ltd. Pp 214.

Akamigbo, G, and Asadu, C.I. A (1986). The influence of topography on some soil parmeters in selected areas of Anambra State, Nigeria. Mg. J. of soil Sc. 6:35-46.

Akande, S.O (1994). Comparative Cost and Return in maize production in Nigeria. Nigeria Institute for Social and Economic Research (NISER) individual Research Project Report, Ibadan: NISER

Anande-Kur, S. (1987). Agricultural and capability evaluation and land use planning in Nigeria. Proc. 15thAnn.Conf. of the soil Sci. of Nigeria, Kaduna, pp. XV-XVIII.

Bremmer, J.M. (1996). Total Nitrogen.In Chemical Methods. Part 3 sparts et al., (Eds)

America society of Agronomy, Madison, Wisconsin 1390pp.

Buol, S.W., R.J. Southward and Dansiel P.A (2003) soil genesis and classification 5th edition, Lowa state university press, Ames USA Pp. 350-355.

Chukwu G.O. (2007). Soil Fertility Capability Classification for Seed Yam on Acid Soils of Southeast Nigeria. Unpublished Ph.D thesis submitted to Federal University of Technology, Minna, Nigeria 190PP.

Chukwu, G. O. and Okonkwo, E.I. (2015). The Roles of a Pedologist in Agro-technology Transfer. Journal of Agriculture and Crops 1 (4); 50 – 56.

Dent, P. and A. Young, 1981. Soil Survey and Land Evaluation, George Alein and Unwin Ltd, London, UK.

Enwezor, W.O., E.J. Udo, N.J. Usoro, Ayotade, KA, and management practice for crops in Nigeria series 2. Federal Ministry of Agriculture, water Resources and Rural Development, Lagos 18.

Ezeaku, P.I. (2011) Soil quality as influenced by Land use and management in the guinea savanna of Nigeria. Nigerian Journal of soil and Environmental Research, 9:1-11.

FAO (Food and Agricultural Organization). 2011, Guidelines for soil profile description. Soil resources, management and conservation service, land and water development division, FAO, Rome.

FDALR (Federal Department of Agricultural and Land Resourses), 1995. Reconnaissance Soil Survey of Imo State, Nigeria (1: 250 000). Soil Report pp 133

Gee, G.W and Boulder (1986). Particle size distribution. In Dan J.H; Topp G.C. (eds). Method of Soils Analysis part 4 physical methods. Soil Science society, Am Books Series No. 5 ASA and SSSA, Madison W.I. Pp. 225-293.

Grossman, R.B. and Rench, T.G. (2002) Bulk Density and Linear Extensibility in dane J.H. and G.C. top (eds). Methods of soil analysis, part 4 physical methods. Soil science soc. Am books series No. 5 ASA and SSSA,madison WI. PP 201-228.

Ohajianaya, D.O. (2006). Resource use efficiency of Land Owners and Tenants in Food Crop Production in Imo State, Nigeria. Journal of Sustainable Tropical Agricultural Research, Vol. 17:26-30.

Ibanga, I.J. (2001) Soil studies, the pedagogical approach Meascot Press Nig. Ltd, Calabar, Cross river State, Nigeria, Pp. 111-115.

Klute, A. and Dirksen, C. (1986). Hydraulic conduction and diffusivity: Laboratory methods. In khite A.(Ed), Methods of soil analysis part 1. Physical and mineralogical methods, 2nded. Agron.Monogr. 9. AS 6, Madison, W.I. Pp. 687-734.

Mcclean, E.O. (1965). Aluminum in: Methods of soil analysis (ed. Black,C.A.) 8 Agronomy No. 9, part2. Amer.Soc. Agronomy, Madison, Wisconsin PP. 978 - 998.

Nelson, D.W. and Sommers L.E (1996). Total Carbon, Organic Carbon and Organic Matter. In D.L. sparks (editor) Pp. 961-1010. Methods o soil analysis. Part 3. Chemical methods SSSA Book series 5, madison, wisconsion, USA.

NRCRI (National Root Crop Research Institute. Umudike) 2011. Agro climatology Report.

Roades, J.D. (1982). Cation Exchange Capacity. In: Page, A. L; Miller, R. H, Keeney, D. R (eds). Methods of Soil Analysis Part2, American Society Agro. Madison W.I, pp. 149-158.

Rossiter, DD.G. (1996). Authomated Land Evaluation System: ALES Version 4.5 User's Manual. December1994 Printing. SCAS Teaching Serves No. T93-2, Revisions 5. Cornell University.

Soil Survey Staff (2010). Keys to Soil Taxonomy. United States Department of Agriculture. 9th edition, 332 PP.

Thomas, G. W (1996). Soil pH and Soil Acidity. In methods of soil Analysis Part3. Chemical Methods Sparks L.D. (ed) SSSA Book series No. 5.