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Soil Fertility and Productivity Test Analysis of Selected Soils of Evite Otu, Aguleri, Anambra East LGA, Anambra State

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ABSTRACT

The study was carried out to assess the fertility and productivity potentials of selected soils of Evite Otu, Aguleri in Anambra East LGA of Anambra State, with a view to making adequate management practices for sustainable crop production in the area. Three mapping units were delineated using the transect method of soil survey. The properties of the surface soil of the units were examined for fertility status while the profile characteristics assessed for productivity potentials for the cultivation of sweet potatoes, cassava, cowpea and lowland rice. Results obtained across the mapping units showed low sand (<53%) and high silt (>26%) fractions with irregular distribution down the depth. Soil reaction varied from very strongly (4.50 - 5.00) to strongly (5.10 - 5.40) acid conditions. Percent organic carbon was generally high (> 1.6 %). Total nitrogen, available phosphorus and exchangeable potassium values were generally moderate. The productivity of mapping unit 1 was limited by imperfectly drained condition (w) and thus, currently marginally suitable (S3) for the cultivation of sweet potatoes, cassava and cowpea but moderately suitable (S2) for lowland rice cultivation. The optimal performance of mapping unit 2 was constrained by fertility (f) thus, currently moderately suitable (S2) for the cultivation of sweet potatoes, cassava and cowpea but marginally suitable (S3) for lowland rice cultivation. Mapping unit 3 was highly suitable (S1) for sweet potatoes; moderate (S2) for cassava; and marginal (S3) for cowpea and lowland rice cultivation. Adequate drainage, liming, application of appropriate fertilizers and suitable soil management would enhance optimal productivity of the land for the crops.

1.0 Introduction

Inadequacies evident in present-day farm planning procedures require that adequate attention be given to soil survey and its interpretation . The ability to maximally harness the potential of any soil begins with a detailed survey and correct interpretation of the survey report (evaluation) of that soil (Udoh, *et al.*, 2013: Amalu and Isong, 2015). Soil characterization and evaluation for various land utilization has been reported as a panacea to achieving food security and sustainable environment (Esu, *et al.*, 2004).

The projection of the world population from the current 7.7 billion to 9.8 billion in 2050 by the UN (2019) shows that climate change and changing consumption patterns of the people may put more pressure on land, thereby increasing the risk of food insecurity, especially in developing countries (FAO, 2011). This pressure can only be averted if growth in agricultural production exceeds population growth through a sustainable intensification of existing agricultural land (FAO, 2011). It is a well known fact that land resources are very significant to agricultural production and cannot be separated from food security (FAO, 2011). Aderonke and Gbadegesin (2013) reported that poor knowledge and appraisal of suitability of parcels of land for agricultural production constitutes the current major problem of agricultural development in Nigeria as it results to poor farm management practices, low yield and an unnecessary high cost of production.

Considering the relevance of the agricultural sector in Nigeria in the area of food production, it is very necessary to evaluate the agricultural potential of the existing soils. This is especially important in an area that is prone to land degradation and where soil productivity is pivotal to food security (Ande, *et al*., 2008). Therefore, there is need for systematic appraisal of our soil resources with respect to their origin, distribution, characteristics, behaviour and potential use in order to develop effective land use system to increase agricultural production on sustainable basis. Keeping these considerations in view, an investigation was undertaken in the study area to assess the fertility status of the soils and suitability of the land for the cultivation of sweet potatoes, cassava, cowpea and lowland rice.

2.0 Materials and Methods

2.1 Study site

The study was conducted on the soils at Ndieke farmland camp, Evite Otu, Aguleri in Anambra East Local Government Area of Anambra State, South-eastern Nigeria. It lies roughly between latitudes 6˚ 41' 2" and 6˚ 41' 24" N and longitudes 6˚ 56' 38" and 6˚ 56' 46" of the Greenwich Meridian with altitudes ranging between 23 and 35 meters above sea level (m asl). The topography is gentle with slope gradient of < 5 %. The terrain generally slopes gradually towards the River Anambra which is the major river in the area. The geology consists mainly of Imo clay shale formation, which is predominantly composed of cretaceous shale of tertiary age and alluvium which were previously laid down by River Niger but later reworked and redeposited by River Anambra (Ngede, *et al*., 2020).

The general climate of the area is humid tropical with bimodally distributed annual rainfall (2000 mm) and mean annual temperature of about 27°C (NOAA/NCEP (2021). Vegetation is largely woody savanna with grassy and herbaceous undergrowth and has been influenced by man activities through bush burning, clearing and land cultivation. The large forest trees known to have been dominant vegetation have given way to shrubs and grasses. ~~The~~ Some varieties of tree crops found in the area include: 'ogbono' (*Irvingia spp*), oil palm (*Elaeis guinensis*), ukpaka (*Pentacletra microphylla*) and mango (*Mangifera indica*). The grasses and weeds in the area include: gambia grass (*Andropogon gayanus*), spear grass (*Imperata cylindrica*) and siamweed (*Chromolaena odarata*). The common arable crops in the area are, rice (*Oryza sativa*), maize (*Zea mays*), cocoyam (*Colocasia esculenta*), yam (*Dioscorea Spp*) and cassava (*Manihot Spp*).

2.2 Methodology

The study site had already been surveyed and divided into four parcels (A – D). The boundary coordinates and elevation data of the site (with reference to surveyed beacons) were recorded using a hand held Global Positioning System (GPS) receiver (*Garmin-etrex 10*). The geo-referenced boundary data obtained through the GPS were processed using Arc GIS to establish the map of the study area (Fig. 1). Field work was thereafter carried out by creating some traverses through the area (transect method). The soils were augered along the traverses for delineation of the mapping units. At each auger point, observations including color, texture, slope, and drainage status were made. These prominent morphological properties of soils obtained from auger borings were used to delineate the site into mapping units. Three mapping units were delineated (AON 1, AON 2 and AON 3) and a total of ten profile pits were dug across the three mapping units. The profile pits were described for their morphological attributes, in line with the procedure recommended by FAO (2006).

Profile sampling was carried out after the soil profile horizons had been identified and described. In addition, top soil Samples (0-20 cm) were collected in a random pattern across the study site for fertility evaluation

All profile pits and surface soil samples locations were geo-referenced using hand-held Global Positioning System and were analyzed for physical properties

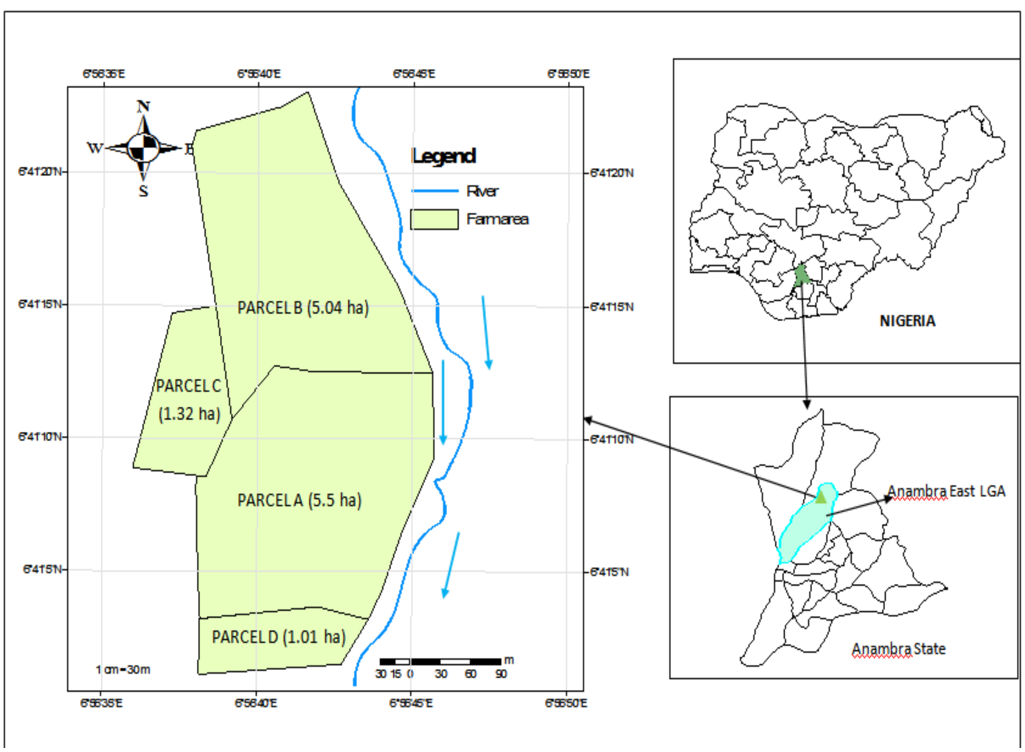

Figure 1: Geo-referenced location of OCCO farm in Aguleri, Anambra East Local Government Area of Anambra State.

2.3 Soil Analysis and Data Interpretation

The soil samples were air-dried and ground to pass through 2 mm sieve. For the determination of total N and organic carbon (OC), a 0.5 mm sieve was used. Analyses of the physicochemical properties were carried out following standard laboratory procedures described by Udo, *et al*. (2009). Particle-size distribution and bulk density were determined by Bouyocous hydrometer analysis and core methods, respectively. Soil pH was measured using a 1:2.5 soil to water ratio, whereas organic carbon (OC) was determined by wet digestion method (Walkley and Black method). Total N was determined by Kjeldahl wet digestion and distillation method, and available P by the modified Olsen method. The cation exchange capacity (CEC) and exchangeable bases were extracted by 1 *M* ammonium acetate (pH 7) method. In the extract, exchangeable Ca and Mg were determined by atomic absorption spectrophotometer (AAS) and exchangeable K and Na by flame photometer. Data were interpreted based on Chude, *et al*. (2011), Sasseville, (2013) and Hazelton and Murphy (2016) ratings for soil data interpretation.

2.5 Land Evaluation Procedure

The method of land evaluation employed in this study was the one developed by Sys *et al*. (1993) for tropical soils and crops. Site characteristics such as climate (c), topography (t), soil physical characteristics (s), wetness (w) and chemical fertility (f) were matched with identified individual requirements known to exert significant influences on the crops yields. For instance, the mapping units were first placed in suitability classes by matching their characteristics (Tables 5 and 6)) with the requirements in Tables 1 - 4. The suitability class of a mapping unit is that indicated by its most limiting characteristic. This follows the well known “Law of the Minimum” in agriculture, which states that crop yield will be determined by the plant nutrient in lowest supply (FAO, 1984). Secondly, each limiting characteristic was rated for the parametric method (Ogunkunle, 1993). Scores were assigned to the characteristics of each mapping unit and suitability calculated as an index of productivity (IP) following square root method stated below:

$$IP = A \; x \sqrt{\frac{B}{100}} \; x \; \frac{C}{100} \; x \; \frac{D}{100} \; x \; \frac{E}{100} \; x \; \frac{F}{100}$$

Where: A is the overall lowest characteristic rating and B, C…F are the lowest characteristics rating for each land quality group. The five land quality groups used in this study were climate (c), topography (t), soil physical properties (s), wetness (w), and chemical fertility (f). Only one member in each group was used because strong correlations exist among members of the same land quality group (e. g. texture and structure in the group of‘s’ (FAO, 1984). Potential index of productivity (IP_p) was calculated without putting the total N, available P and exchangeable K into the ‘f’ group, while the current (actual) index of productivity (IP_c) was calculated with the total N, available P and exchangeable K forming part of the ‘f’ group. Suitability classes such as high (S1), moderate (S2), marginal (S3) and none (N) are equivalent to IP values of 100-75 %, 74-50 %, 49-25 %, and 24-0 % respectively.

2.6 Geo-spatial Analysis

The spatial data of the site perimeter, profile pits and the surface soil samples were processed in Geographic Information System (GIS) application to produce the map of the project site (Fig. 1). Following the Framework for land evaluation, multi-criteria evaluation technique in GIS was used to model fertility indices of the study area (FAO, 2016). Based on the extent to which the soil properties meet the nutrient rating index (Chude, *et al*., 2011), and with respect to the coordinates of the surface sample locations, the thematic layer was prepared according to the rating scale as very low, low, medium, and high. All the scaled thematic layers were assigned weighted values and integrated using map algebra in GIS to produce soil fertility maps of the project site (Figures 3 – 6).

Table 1: Land use requirements for sweet potato cultivation

Land qualities	**Unit**	**S1**	**S2**	**S3**	**N**
		100-95 %	**94-85 %**	**84-40 %**	**39-0 %**
Climate (c)					
Mean annual Rainfall	(mm)	1600-1100	1100-900	900-500	<500
Mean annual Temp.	(^{O}C)	21-30	>18<21	>12	<12
Wetness (w)					
Soil drainage		Well drained	Moderate	Poor	Very poor
Fertility (f)					
Total N	(%)	>0.12	0.1-0.12	<0.1	-
Avail P	(mgkg^{-1})	>25	6-25.	<6	-
Exch. K	(cmol/kg)	>0.6	0.3-0.6	<0.3	-
pH		5.5-6.8	6.8-7.8/ 5.0-5.4	>7.8 <5.0	-
Organic C (0-15) cm	>1.5	1.0-1.5	<0.4-1.0	<0.4	
CEC	(cmol/kg)	>16	3-16	<3	-
Base saturation	(%)	>35	20-35	<20	-
Soil texture		L, SL	LS, CL	S, SCL	C
Soil depth	(cm)	>100	100-75	75-50	<50
Slope	(%)	0-5	5-12	12-20	>20

(Modified from Sys *et al.,* 1993)

Key: S_1 = highly suitable, S_2 = moderately suitable, S_3 = marginally suitable, N_1 = currently not suitable, C = Clay, CL= clay loam, L = loam, SiC = silty clay, LS = loamy sand, SL= sandy loam, SCL = sandy clay loam, S = sand, SC = sandy clay.

Similarly, each of the land qualities was matched with the agronomic requirements of the test crops (sweet potatoes, cassava, cowpea and lowland rice). Based on the extent to which the land quality meets the requirements of each crop, thematic layer was classified according to the rating scale of suitability as high, moderate, marginal and non-suitable. All the scaled thematic layers were assigned a weighted value and integrated using map algebra in GIS to produce land suitability maps of the farmland for the cultivation of the selected crops (Figures 7-10).

Table 2: Land use requirement for cowpea cultivation

Land qualities	S1 (100-95%)	S2 (94-85%)	S3 (84-40%)	N1 (39-20%)	N2 (19-0%)	
Climate (c): Annual rainfall (mm)	>1200	1000-1200	800-1000	600-800	<600	
Length of rainy season (months)	>5	4-7	3-4	2-3	<2	
Mean annual Temp. (^oC)	>25	22-25	20-22	18-20	<18	
Relative humidity (%)	>27	70-75	65-70	60-65	<60	
Topography (t): Slope (%)	0-4	4-8	8-12	12-16	-	
Wetness (w): Flooding	Fo	Fo	F1	F2	F2	
Drainage	Good	Good	Moderate	Moderate	Poor	
Soil Physical properties (s)						
Texture	LS	SL	SC	SCL	C,CL	
Depth (cm)	>100	90-100	50-90	25-50	>25	
Fertility (f): CEC (cmol/kg)	>10	8-10	6-8	4-6	<2	
Base saturation	>70	60-70	40-60	20-40	0	
pH	>6.0-6.5	6.0-7.0	5.5-6.0	5.0-5.5	<4-7.5	
Organic carbon (%)	>2.0	1.5-2.0	1.25-1.5	1-0-1.25	<1.00	
Ca (mole)	0-8-0.9	0.7-0.8	0.6-0.7	0.4-0.6	<0.2	
Total N (%)	>0.05	0.02-0.05	<0.02	<0.02	<0.02	-
Avail. P (mg/kg)	>20	16-20	12-16	8-12	<4.0	
Exch. K	>0.6	0.3-0.6	0.2-0.3	0.2	<0.2	-

Modified by Sys, *et al* (1991)

Table 3: Suitability ratings for lowland rice requirements

Land qualities/characteristics	**S1**	**S2**	**S3**	**N1**	**N2**
	95-85%	**84-60%**	**59-20%**	**39-20%**	**19-0%**
Climate (c)					
Annual rainfall (mm)	>1,400	1,200-1,400	950-1,100	850-900	<850
Temperature (^OC)	>30	18-30	>16	>12	
Soil physical characteristics (s)					
Soil Depth (cm)	>50	20-50	5-10	<5	-
Texture	SiCL, CL	SL,SCL	SL,SCL	LS	S, CS
Drainage	poor	imperfect	moderate	good	very poor
Topography (t) Slope (%)	0-2	2-5	5-7	7-10	>10
Chemical properties (f)					
Soil pH	-	5.5-7.5	52.-5.5	$\leq$5.5	$\geq$5.2
Total N (g/kg^{-1})	>0.2	0.1-0.2	0.05-0.1	<0.05	-
Soil Organic Carbon (%)	2-3	1-2	3-4	>4	-
CEC ($cmolkg^{-1}$)	>16	10-16	5-10	<5	-
Available P ($mg\ kg^{-1}$)	>20	15-20	10-15	<10	-
Exch. K ($cmolkg^{-1}$)	>0.2	0.1-0.2	<0.1	<0.1	

Source: Sys (1991), Mongkolsawat (1997)
S_1 = highly suitable, S_2 = moderately suitable, S_3 = Marginally suitable, N_1 = currently not suitable, N_2 = permanently not suitable, C = clay, CL= clay loam, SCL=sandy clay loam, L = loam, SiCs = silty clay sand, LS = loamy sand, SiCL = silty clay loam, S = sand, SC = sandy clay, LFS=loamy fine sand

Table 4: Land Use Requirement for Cassava

Land Quality	100 – 95 (S1)	94 - 85 (S2)	84 – 40 (S3)	39 – 0 (N)
Climate (c)				
Mean annual rainfall (mm)	1500 - 1100	1100 - 900	900 - 500	< 500
Mean annual temperature (^0C)	18 – 30	16 – 18/30 - 35	< 12 or > 35	any
Topography (t) *Slope (%)*	0 -5	5 - 12	– 20	>20
Wetness (w) Drainage	Well drained	Imperfect	Poor	Very poor
Soil physical characteristics (s)				
Texture and Structure	L, SC, CL	LS,SL,SCL, SiCL	S, SiC	C
Soil depth (cm)	> 100	100 - 75	75 - 50	< 50
Fertility (f)				
CEC (cmolkg^{-1} clay)	>16	16 - 3	< 3	any
Base saturation (%)	>35	35 - 20	< 20	any
Organic carbon (%) 0-15cm	> 2	1.2 -2.0	2.0-0.8	<0.8
pH	6.1 – 7.3	7.4-7.8 or 5.1-6.0	>8.4 or <3	any
Total Nitrogen (%)	>0.2	0.2 – 0.1	<0.1	any
Exch. K cmolkg^{-1})	>0.6	0.3-0.6	<0.3	-
Available P (mgkg^{-1})	>25	25 - 6	< 6	Any
Exchangeable K (cmolkg^{-1})	>0.6	0.6 – 0.3	< 0.3	any

Key: C-Clay, CL=Clay Loam, L=Loam, SiCL= Silty Clay Loam, SL= Sandy Loam, SCL = Sand Clay Loam, SC= Sandy Clay, LS=Loamy Sand.
Source: Sys *et al.*, (1991); Mongkosalwat *et al*., (1997).

3.0 Results and Discussion

3.1 Soil Resources and their Interpretation

The criteria for defining mapping units were based on some important soil morphological attributes such as soil consistency, colour and soil drainage after several auger investigations. Consequently, three mapping units were identified as shown on the map (Figure 2). They are designated as AON I, AON 2 and AON 3. The land characteristics of the mapping units are presented in Table 5.

3.1.1 Mapping unit 1

This mapping unit occupied 3.66 ha, about 28.44 % of the farmland. Sandwiched between nearly flat (2 %) and gently sloping terrains (<3.5 %), the soils were very deep (> 170 cm) but imperfectly drained with matrix colours ranging from very dark gray (5YR 3/1) surface overlying yellowish red (5YR 5/6) subsurface horizons. The subsurface horizons (30 – 135 cm) were imperfectly drained as abundant mottles characterized these depths. The surface horizons were crumb-structured over sub-angular blocky with consistence (moist) varying from friable surface to firm.

There was no definite pattern of particle size (sand, silt and clay) distribution down the soil depth. For instance, clay fractions increased from the surface soil to upper subsurface and suddenly decreased down the depth. This is a marked pedogenic (soil forming) process – pedoturbation (soil mixing) attributable to the formation of cracks in the mid-subsurface (Amusan, 2006). The relatively high silt fractions in the soil could be attributed to the depositional effects of occasional flooding caused by the nearby Anambra River. The bulk density values (1.36-1.58g/cm^3) were lower than the critical limit values (1.75 – 1.80 gcm^{-3}) for root penetration. This implies that there will be no excessive compaction inhibiting root development (Ojeniyi, 2002).

The chemical properties of the soils show that this mapping unit falls within the strongly to moderately acid class (5.1 to 5.6), which is not ideal for most crops to thrive well as most nutrient elements especially, phosphorus will be fixed and thus, will not be readily available for absorption by plant roots. Therefore, the sustainable productivity of this mapping unit is anchored on adequate liming to reduce the acid effects and ensure adequate availability of soil nutrients to crops.

The soils are high in organic carbon (> 1.5 %), moderately low in total nitrogen but moderate in exchangeable potassium and available phosphorus. Effective cation exchange capacity (ECEC) is very low while the percentage base saturation is high (> 60 %). In addition to liming, application of nitrogen (N), phosphorus (P) and potassium (K) fertilizer and adequate drainage are also necessary for a sustainable crop production in this mapping unit.

3.1.2 Mapping unit 2

This unit covers 2.89 ha (22.46 %) of the surveyed area. The unit consists of gently sloping landscape with slopes ranging between 3 and 4 %. The soils are deep and moderately drained. They have cracks in the lower horizons. Soil matrix colours range from very dark gray – dark brown (5YR 3/2 - 7.5YR 4/2 sandy loam surfaces over yellowish red-reddish yellow (5YR 5/6 -7.5YR 6/6) sandy clay loam – sandy clay sub-soils.

The soils are strongly acid (pH 5.1 -5.5). The soils have high organic carbon (1.6-2.3 %) while total nitrogen values range from low -moderate (0.13-0.19 %). Exchangeable potassium (0.36-0.38) and available phosphorus (12.15-13.83) are moderate. Effective cation exchange capacity (ECEC) is very low while the percentage base saturation is very high (> 65 %). The bulk density values are lower than the critical limits for root penetration (1.75-1.80g/cm^3). The strongly acidic nature of this unit will require proper liming for adequate availability of nutrients to crop. There is need for application of nitrogen, phosphorus and potassium fertilizers. Adequate drainage is also necessary to improve soil aeration.

3.1.3 Mapping unit 3

The unit occupies 6.31 ha (49.03 %) of the total area surveyed. Similar to mapping unit 2, the soils of this unit are located o a gently sloping terrain with slope gradients ranging between 3 and 5 %. The soils are deep and well drained. They have cracks in the lower horizons. Soil matrix colours range from very dark gray – dark brown (5YR 3/2 - 7.5YR 4/2 sandy loam surfaces over yellowish red-reddish yellow (5YR 5/6 -7.5YR 6/6) sandy clay loam – sandy clay subsoils.

The soils are strongly acid (pH 5.3 -5.5). The soils have high organic carbon (1.5-3.2 %) while total nitrogen values range from low -moderate (0.12-0.18 %). Exchangeable potassium (0.30-0.40) and available phosphorus (10.60-12.04) are moderate. Effective cation exchange capacity (ECEC) is very low while the percentage base saturation is very high (> 65 %). The bulk density values are lower than the critical limits for root penetration (1.75-1.80g/cm^3). The strongly acidic nature of this unit will require proper liming for adequate availability of nutrients to crop. There is need for application of nitrogen, phosphorus and potassium fertilizers.

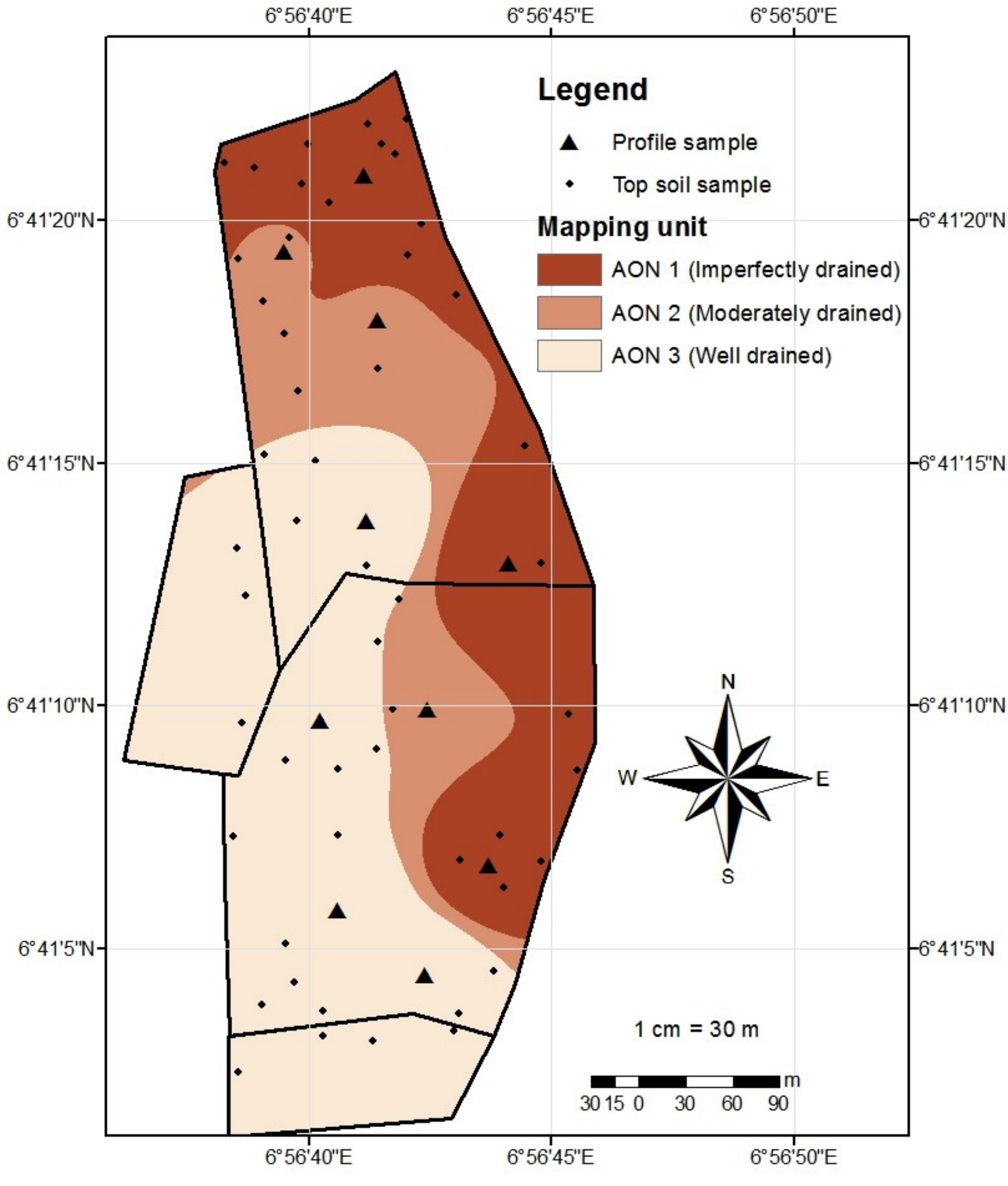

Figure 2: Delineation of mapping units and location of sample points

Table 5: Land characteristics of the study site

Land characteristics	Mapping unit 1	Mapping unit 2	Mapping unit 3
Climate (c)			
Annual rainfall (mm)	1,400 - 1,800	1,400 - 1,800	1,400 - 1,800
Temperature (^{o}C)	22 - 29	22 - 29	22 - 29
Topography (t)			
Slope (%)	< 2	< 3.5	< 5
Wetness			
Drainage	Imperfect	Moderate	Well drained
Colour			
Topsoil	5YR 3/1	7.5YR 4/2	7.5YR 3/2
Subsoil	5YR 5/6	7.5YR 6/6	7.5YR 4/8
Consistence			
Topsoil	Friable	Friable	Friable
Subsoil	Firm	Firm	Firm
Structure			
Topsoil	Crumble	Crumble	Crumble
Subsoil	Subangular blocky	Subangular blocky	Subangular blocky
Area covered (ha)	3.66	2.89	6.31
Soil physical characteristics (s)			
Sand (%)	44	44	53
Silt (%)	26	31	27
Clay (%)	30	25	20
Texture	Clay loam	Loam	Sandy clay loam
Soil depth (cm)	>175	> 180	>180
Soil fertility (f)			
ECEC (cmol/kg)	6.57	7.14	7.25
BS (%)	70.31	71.43	72.25
Organic carbon (%)	2.51	2.01	2.04
pH	5.33	5.28	5.36
Total nitrogen (%)	0.19	0.17	0.16
Available P (mg/kg)	17.90	18.12	16.40
Exchangeable Ca (cmol/kg)	5.50	5.01	4.95
Exchangeable Mg (cmol/kg)	2.33	2.25	1.82
Exchangeable K (cmol/kg)	0.35	0.37	0.36
Exchangeable Na (cmol/kg)	0.28	0.31	0.30
Exchangeable acidity (cmol/kg)	1.62	1.76	1.64
Exchangeable Al (cmol/kg)	0.59	0.61	0.45

3.2 Soil Fertility Status

The entire farmland was generally strongly acidic (<5.5) except few portions that were moderate (Fig. 3). At this pH value, some soil nutrients especially, phosphorus will not be readily available for absorption by plant roots. Therefore, adequate liming would be required to reduce the acid effects and ensure adequate availability of the nutrients to crops. Organic carbon contents (Fig. 4) were generally high across the farmland. The high accumulation of organic matter content was consequent upon higher vegetal cover on the soil surface over a long period of fallow. Therefore, there is need to adopt cultural practices such as minimum tillage operation, mulching, organic manuring, etc that will encourage the return and incorporation of plant/crop residues into the soil to sustain/increase the level of soil organic matter Ojeniyi, 2002). The percentage total nitrogen values (Fig. 5) ranged between low and moderate. The area is relatively under the influence of nitrogen deficits which may be attributed to volatilization especially, under high temperature regimes and denitrification processes. The exchangeable bases (Ca^{2+}, Mg^{2+}, Na^{+} and K^{+}) were generally low except K^{+} which was moderate (Fig. 6). The available phosphorus was moderate. Therefore, maintenance of fertility status of the farmland is necessary. This can be achieved through: liming (to reduce acidity and make nutrients more readily available); application of nitrogen, phosphorus and potassium fertilizers, and adoption of cultural practices such as minimum tillage operation, mulching and organic manuring that will encourage the return and incorporation of plant/crop residues into the soil to sustain/increase the level of soil organic matter.

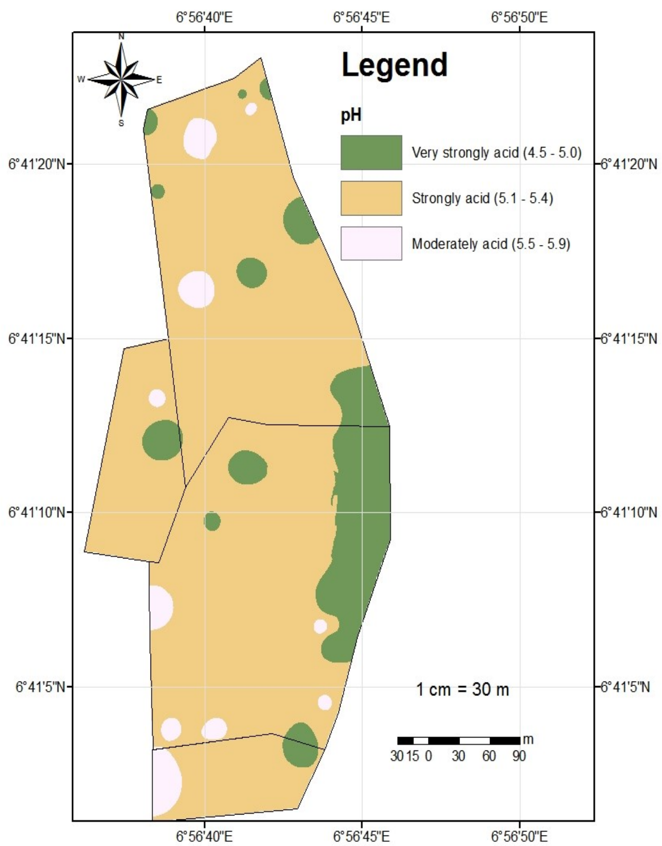

Figure 3: pH distribution of soil of the study site

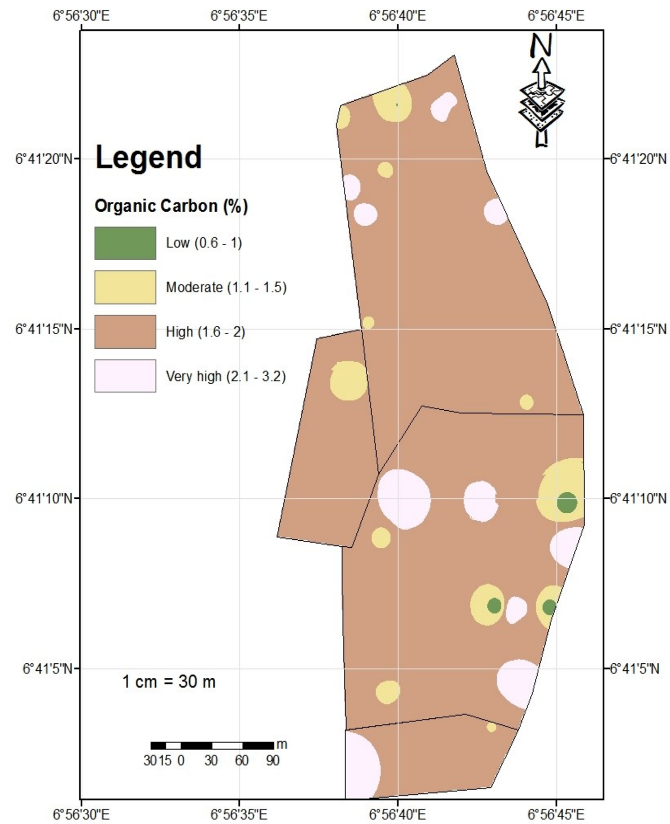

Figure 4: Organic Carbon distribution in soil of the study site

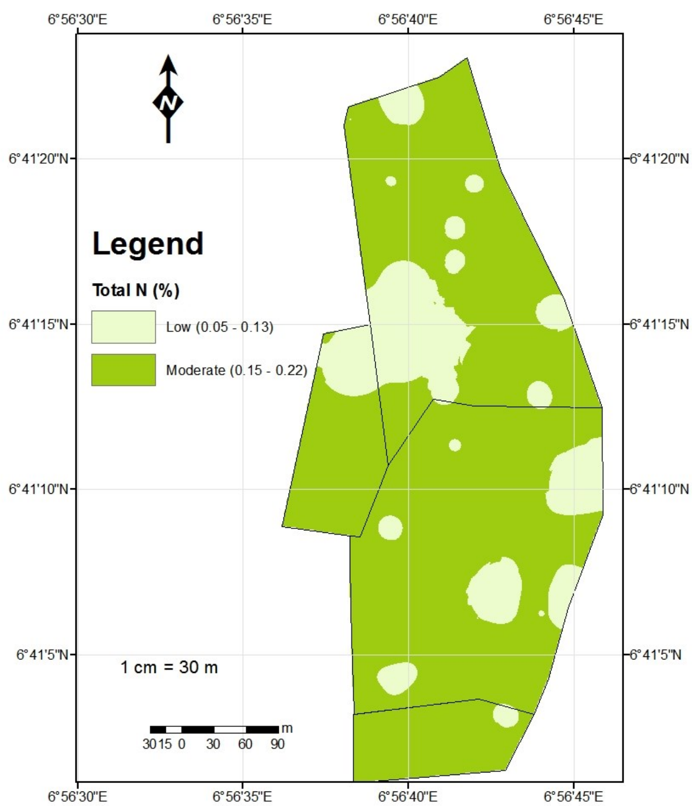

Figure 5: Total Nitrogen distribution in soil of the farmland

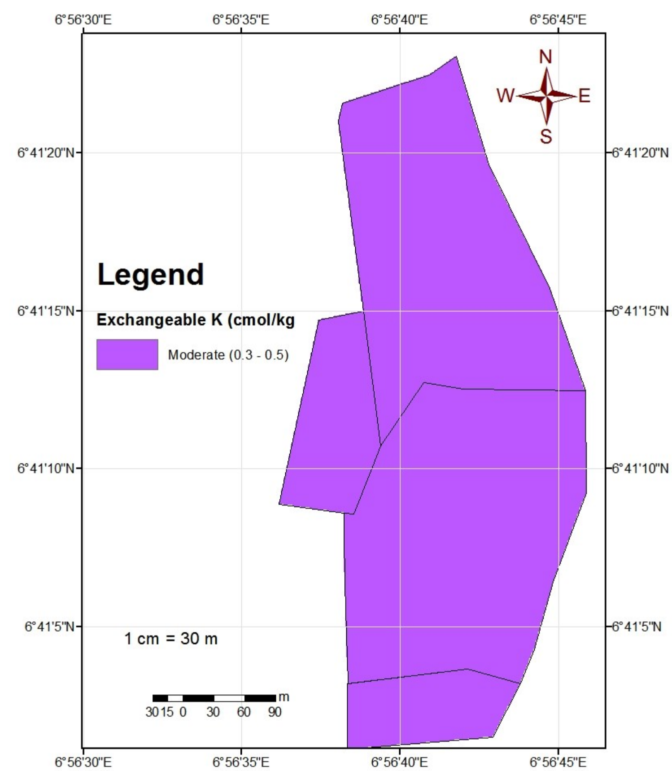

Figure 6: Distribution of exchangeable K in soil of the farmland

3.3 Land Suitability Evaluation

Land suitability evaluation of the three mapping units studied for the cultivation of sweet potatoes, cassava, cowpea and rice using the parametric method was determined. Results of matching agronomic requirements (Tables 1-4) for production of the test crops with land characteristics (Table 5) are shown in aggregate suitability class score (Table 6). Climate was not a constraint to the production of sweet potatoes, cassava, cowpea, lowland rice in the farmland and environs because there were more than five months of steady rainfall. Consequently, these crops would do best when planting and developmental stages are programmed to fall within the rainy months in the year. Topography (slope gradient) of the entire mapping units, < 5 % was highly suitable for optimal production of the selected crops (Sys *et al.*, 1993) and therefore, would not pose any limitation to optimal performance of the crops on the farmland and its environs. Similarly, soil depth in the study area was greater than 100 cm and is considered adequate for sustainable production of any crop (Sys *et al.*, 1993).

In terms of soil wetness (drainage), mapping units 2 and 3 had moderate to good drainage, while mapping unit 1 had imperfect drainage. Mapping unit 1 is the only unit that has the tendency to be flooded during the months of July and/or September, the two months that constitute the two rainfall peaks in the year. Therefore, imperfect drainage in mapping unit 1 is considered a limiting factor to the optimal performance of the unit for the selected crops except lowland rice. The entire farmland was strongly acid and deficient of basic nutrients such as nitrogen, available phosphorus and exchangeable potassium. These are limitations to the optimal performance of the soils for production of the selected crops.

The aggregate assessment of study site has shown that the optimal performance of mapping unit 1is constrained by imperfectly drained condition (w) of the unit and thus, currently puts the unit as marginally suitable (S3w) for the cultivation of sweet potatoes, cassava and cowpea but moderately suitable (S2f) for lowland rice cultivation with fertility as the major limitation. The productivity of mapping unit 2 is constrained by fertility (f) thus, currently moderately suitable (S2f) for the cultivation of sweet potatoes, cassava and cowpea but marginally suitable (S3f) for lowland rice cultivation, deficit in fertility. In similar development, the suitability of mapping unit 3 was high (S1) for sweet potatoes; moderate (S2f) for cassava and marginal (S3f) for cowpea with fertility as constraint. However, inadequate soil moisture and low fertility status classified mapping unit 3 as marginally suitable (S3wf) for optimal production of lowland rice (Figures 7 - 10).

Soil fertility status especially; available phosphorus and exchangeable potassium, soil texture and the imperfect drainage condition of portions near the river have been found out to currently limit the potentials of the soils for optimal production of these crops.

Table 6: Aggregate Suitability Scores of the Mapping Units for the Cultivation of the Test Crops

Crop	Mapping unit 1	Mapping unit 2	Mapping unit 3
Sweet potatoes			
Potential	S3	S1	S1
Actual	S3	S2	S1
Limitation	w	F	
Cassava			
Potential	S3	S1	S1
Actual	S3	S2	S2
Limitation	w	f	f
Cowpea			
Potential	S3	S2	S2
Actual	S3	S2	S3
Limitation	w	f	f
Lowland rice			
Potential	S2	S2	S3
Actual	S2	S3	S3
Limitation	f	f	w, f

Aggregate suitability class scores: S1 =75-100; S2=50-74; S3=25-49; N1=15-24; N2=0-14

Note: f = fertility, w = wetness (drainage)

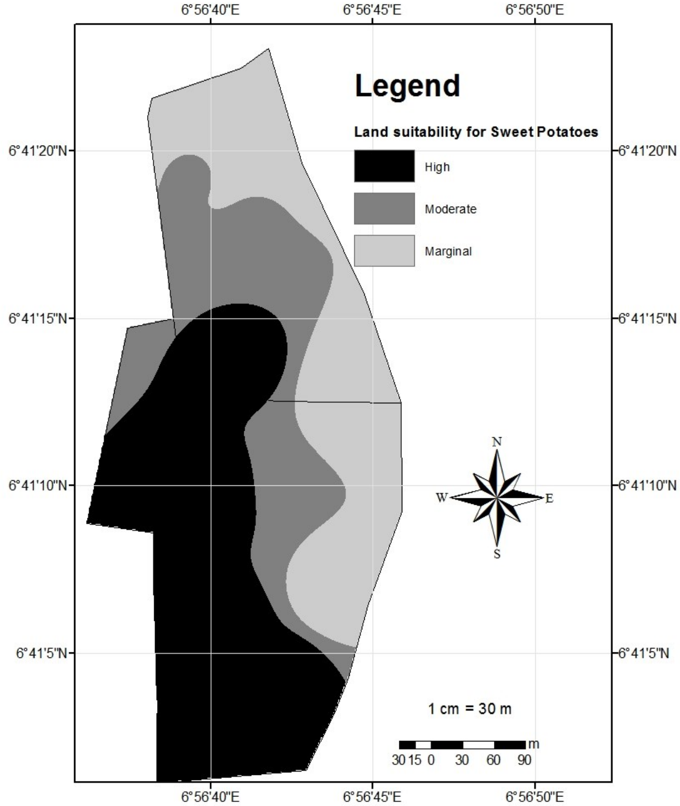

Figure 7: Land suitability of the site for sweet potatoes

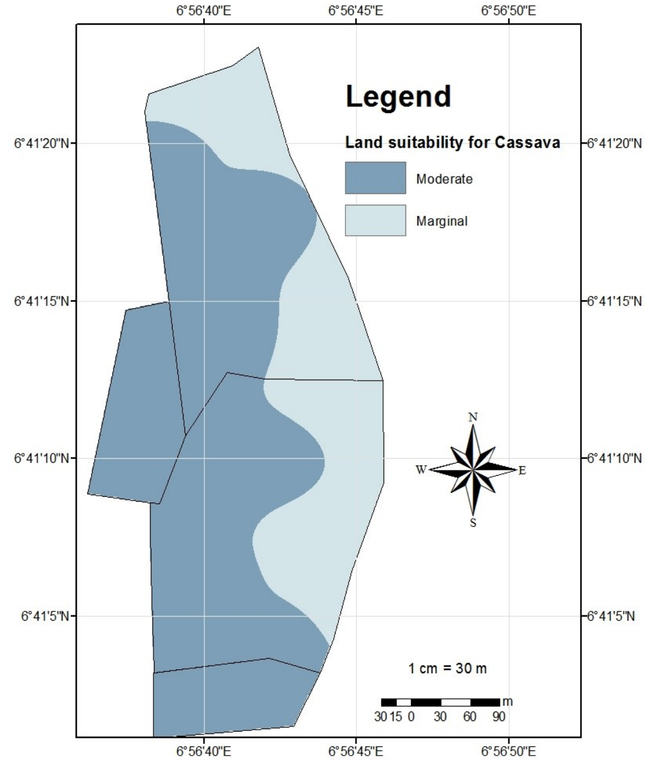

Figure 8: Land suitability of the site farmland for cassava

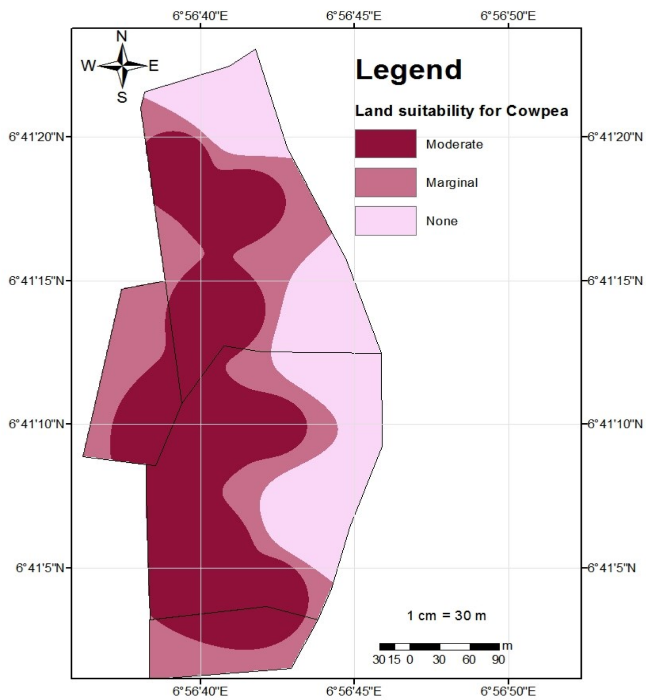

Figure 9: Land suitability of the site for cowpea cultivation

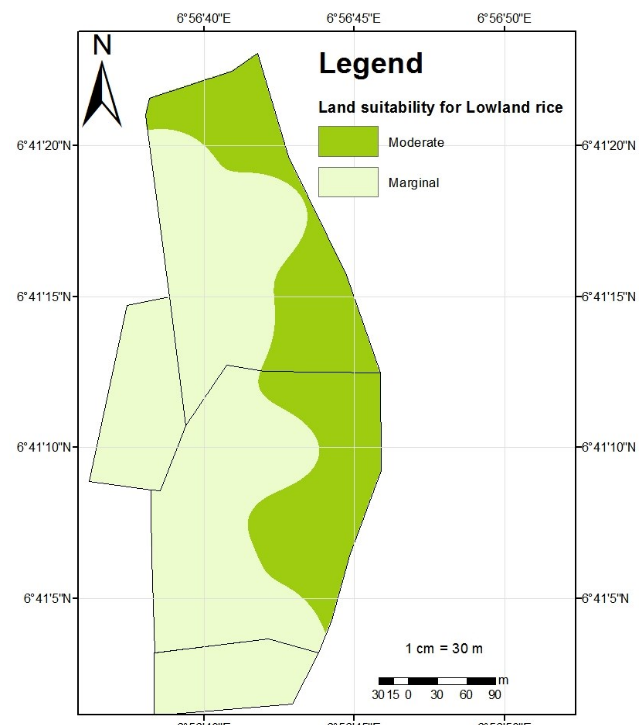

Figure 10: Land suitability of the site for lowland rice cultivation

4.0 Conclusion and Recommendations

The farmland was characterized as imperfectly, moderately and well drained moisture conditions. The observed friable consistence and crumb structure of the top soil will ensure good tillage operation and easy penetration of plant roots but indicative of very fragile soils. The soils were strongly acid in reaction with moderately low values of total nitrogen, available phosphorus and exchangeable potassium; although high in organic matter.

Suitability assessment confirmed that climate, topography and base saturation are optimum for the cultivation of the selected crops. However, the optimal performance of mapping unit 1 is limited by imperfectly drained condition (w) and thus, currently marginally suitable (S3w) for the cultivation of sweet potatoes, cassava and cowpea but moderately suitable (S2f) for lowland rice cultivation. The productivity of mapping unit 2 was constrained by fertility (f) thus, currently moderately suitable (S2f) for the cultivation of sweet potatoes, cassava and cowpea but marginally suitable (S3w) for lowland rice cultivation. The aggregate suitability of mapping unit 3 was high (S1) for sweet potatoes; moderate (S2f) for cassava; and marginal (S3f) for cowpea, lowland rice. The unit was deficient of fertility (f).

Generally, the optimal productivity of the soils farmland was constrained by poorly drained condition of mapping unit 1 and overall low fertility status of the soils.

Adequate drainage, liming, application of appropriate fertilizers and suitable soil management would enhance optimal productivity of the land for the test crops.

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