Soil Survey and Land Suitability evaluation for Cocoyam (*Xanthosoma Species*) and Mungbean (*Vigna radiata*) at Umuchigbo Iji Nike, Enugu State, Nigeria

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ABSTRACT

The study was conducted to inventorize, a farmland at Umuchigbo IjiNike, Enugu, Southeast, Nigeria and evaluate its suitability for the cultivation of cocoyam (*Colocasia species*) and mung bean (*Vigna radiata*). Flexible grid soil survey method was adopted and six representative pedons excavated in three soil mapping units (UIN I-III). Pedons were described *in-situ* for morphological attributes and samples collected from the pedogenetic horizons were analyzed for physical and chemical properties. Results showed that UIN I was relatively deep (60–115cm) and moderately drained with sandy clay loam, underlain by clay. However, UIN II and UIN III were moderately deep (60–80cm) and well drained with sandy clay loam and loam overlying clay loam subsoil. The pH (water) ranged from moderately to slightly acidic (5.5–6.3). Organic carbon (2.02–3.49%), total N (0.20–0.28%), available P (36.0-55.3mg/kg) and base saturation (82.6–91.7%) were high whereas, exchangeable bases were low. Two soil classes were identified: Typic Plinthustafs and Typic Plinthusteps (USDA) correlated as Plinthic Lixisols and Plinthic Cambisols (WRB) respectively. Suitability assessment revealed UIN I as marginally suitable (S3t) whereas, UIN II and III were moderately suitable for cocoyam. However, all the units were moderately suitable (S2f) for mung bean cultivation. Identified constraints were low pH, fertility and effective soil depth. Ridging across the slope in UIN I and phosphorous fertilization in UIN II and III would improve cocoyam performance. Adequate drainage of UIN I and liming of the entire site would enhance optimum performance of mung bean.

Keywords: Soil taxonomy, cocoyam, mung bean, suitability evaluation

INTRODUCTION

In Nigeria, agriculture has not been able to supply adequate quantities of food and raw materials to agro-based industries. This is attributed to many factors, among which is lack of adequate knowledge of our soils, their potentials and limitations for various uses. Soil survey has been reported as a veritable tool to gather reliable information about the soil and environmental factors that will help Soil Scientists to make judicious decisions about sustainable soil management or use of land (Esu, 2004; Lekwa *et al.*, 2004). Soil survey involves a combination of field and laboratory activities intended to identify the basic morphological, physical and chemical properties of soils (soil characterization), establish the distribution of those soils at specific map scales (classification and mapping).

It is pertinent that if the potentials of agricultural land should be maximized, land use should not be based, primarily, on the needs and demands of the users, but also on the suitability of such a land, for the intended use, in order to derive maximum benefit and achieve environmental sustainability. Land evaluation is the first step in agricultural planning for sustainable crop production because it will guide decisions on land utilization, in such a way that resources are optimally used, resulting in sustainable environmental management (Fasina, *et al.*, 2015)

A reconnaissance soil survey of Nigeria conducted by the Federal Department of Agricultural Land Resources (FDALR, 1990)has not been able to capture reliable soil information about rural agrarian communities due to large scale (1:650,000–1:1,000,000) used. This has led to dearth of information on soil sustainability for crop production in the rural and agrarian communities especially, Umuchigbo Iji Nike, Enugu State Local Government Area of Enugu State.

Cocoyam (*Xanthosoma* species) is a staple root and tuber crop inthe farming system of southeast agro-ecological zone of Nigerian (Chukwu, 2011). The corms and cormels are eaten in various food forms while the leaves and flowers are used as spices to garnish and flavour food (Chukwu, 2011; Chukwu *et al.,* 2012). It is recommended in ethno and clinical medicine, for the treatment of diabetes, heart disease and cancer (Simsek and El, 2015, Kundu *et al.*, 2012). Cocoyam is adjudged to be nutritionally betterthan cassava and yam, in terms of its digestibility, contents of crude protein and essential minerals, such as Ca, Mg and P (FAO, 1990).

Mung bean sometimes called green gram (*Vigna radiata*) is commonly grown for its edible dry seeds and fresh sprouts;highly nutritious source of food with a protein content of 25 % (Oplinger, 1990; Agugo, 2006). In China, mung bean has been consumed as a common food for more than 2000 years because of its well-known health benefits such as reduction in gastro-intestinal problems, detoxifying role, skin moisture reduction, and decreases chances of stroke and increase mental alertness (Agugo, 2006).

The current domestic production of cocoyam and mung bean in Nigeria seems not to meet the growing demand. Oplinger(1990) reported that the shortfall has been consequent upon low yielding varieties and more importantly impoverished soils that are used for their production among others However, ineffective and unplanned use of agricultural land is serious challenge in agricultural productivity in Nigeria (Fasina *et al*, 2007). Therefore, understanding the characteristics of soils in an area is very crucial for the productive and sustainable management of such soils to better the lives of the inhabitants.

Keeping these considerations in view coupled with paucity of soil information in the study area, investigations was undertaken to characterize, classify and assess the land suitability of the site for cocoyam and mung bean cultivation.

MATERIALS AND METHODS

Study area

The study was conducted at Umuchigho Iji Nike, South-eastern Nigeria located within latitudes 6^o 29' 10" and 6^o 29' 50" N and longitudes 7^o 33' 20" and 7^o 33' 58" E(Figure1). The study covered about 100 ha of land area with altitude ranging between 162 and 212 meters above sea level.

The geology lies within the Anambra Basin which comprises Enugu Shale, Mamu Formation Ajali Sandstone and Nsukka Formation (Adeigbe and Salufu, 2011; Eze 2014). The Enugu Shale is part of Nkporo Group which is the oldest succession within Anambra Basin, deposited in the Cretaceous age(Nwajide, 1990; Adeigbe and Salufu, 2011). The Nkporo Group comprises Asata/Nkporo Shale Group, Owelli Sandstone and Enugu Shale (Obi, 2000) (Figure2).

The area has a humid tropical climate with wet (April to October) and dry (November to March) seasons. Rainfall ranges from about 1,200 to 2,000 mm and is bimodal with peaks in July and September. Annual mean air temperature is about 28.3^o C and relative humidity ranges from 41 – 63.6 per cent (ANON, 2023).The native vegetation has almost completely been replaced by secondary forest of wild oil palm trees of various densities of coverage as well as woody shrubs and various grasses that form the under growth.Agricultural land use is characterized by various perennial and annual crop species in the homestead and agroforestry systems. The tree crops include oil palm (*Elaeis guineensis),* mango (*Mangifera indica)*, banana and plantain (*Musa spp.),* guava (*Psidium guajava)*, native pear (*Dacryodes edulis)*, oil bean tree (*Penthaclethra macrophylla)*, and avocado pear (*Persea americana).* Some of the arable crops include cocoyam (*Colocasia* and *Xanthosoma* spp), cassava (*Manihot esculenta)*, and yam (*Dioscorea spp.)*

Geo-spatial analysis and soil sampling

A perimeter survey of the farmland was carried out with the coordinates (latitudes and longitudes) and elevation datageo-referenced using a hand held Global Positioning System (GPS) receiver (*Garmin-etrex*).Flexible grid method of soil survey was adopted using roads that surround the farmland and footpaths within it as traverses.The morphological, physical and chemical properties of the soils of the area were studied through field observation and laboratory analyses. Auger investigations were made at various points across the farmland at 0-15 and 15-30 cm depths consequent upon changes in landscape features, such as colour, slope, vegetation and drainage. The spatial data of the perimeter and auger points from various physiographic units across the site were input into the ArcMap 10.2 software in Geographic Information System (GIS) application for the production of the soil boundary delineation map.Consequent upon observed changes in physiographic features coupled with differences in auger investigations, three soil mapping units were delineated and identified as UIN I, II and III. One representative profile was excavated in UIN II (17.10 ha), two in UIN III (27.60) and three in UIN I (55.30 ha) depending on the extent of coverage (Table 3). With reference to the Guidelines for Field Soil Descriptions (FAO, 2006), the pedons were described *in situ* for their morphological properties, using the Munsell chart for soil colour description. Soil samples were collected from all identified horizons, transported to the laboratory, processed and analyzed for physical and chemical properties.

Soil analysis and data interpretation

The soil samples collected from every identified horizon were air-dried and ground to pass through 2 mm sieve. For the determinations 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. Particle-size distribution was determined by Bouyoucos hydrometer methods (Gee and Or, 2002). Soil pH was measured using a 1:2.5 soil to water ratio (Thomas, 1996) whereas soil organic carbon was determined by the wet oxidation method of Nelson and Somers (1982). Total N was determined by Kjeldahl wet digestion and distillation method (Bremner, 1996).Available P was determined using Bray-1 extract (Olsen and Summer, 1982). Total exchangeable bases were determined by extracting with neutral normal ammonium acetate (NH_4OAC) at pH 7.0.Exchangeable K^+ and Na^+ in the extract was determined using a flame photometer while exchangeable Ca^{2+} and Mg^{2+} was determined using Atomic Absorption Spectrophotometer (AAS)(Jackson, 1962). The exchangeable acidity, that is, hydrogen (H^+) and aluminium (Al^{3+}) was determined by titrimetric method. Effective cation exchange capacity was calculated by the summation of all exchangeable bases (Na^+, Ca^{2+}, Mg^{2+} and K^+) and exchangeable acidity ($Al^{3+}$and H^+).

Base saturation (BS) was calculated using the formulae:

$$BS = \frac{TEB}{Na^+ + Ca^{2+} + Mg^{2+} + K^+ + Al^{3+} + H^+} \times \frac{100}{1} \quad ...\text{Equation 1.}$$

Data were interpreted based on Chude *et al.* (2011) soil nutrient interpretation.

Soil classification

Based on the morphological, physical and chemical properties obtained as well as climatic data, the soils were classified using the USDA Soil Taxonomy System (Soil Survey Staff, 2014) and World Reference Base (WRB, 2014) systems of soil classification

Land suitability evaluation

Simple limitation (non-parametric) method of land suitability evaluation was adopted. Land characteristics were divided into quality groups. These include climate-**c** (annual rainfall, annual temperature, and mean relative humidity), Topography-**t** (slope), wetness-**w** (oxygen availability-drainage), soil physical characteristics-**s** (rooting condition-soil depth, structure, texture) and fertility-**f** (nutrient availability and retention-pH, organic matter, available P, exchangeable K, Mg, Ca, total N, CEC and base saturation). It is assumed that members of the same group have strong correlation among members (Udoh and Ogunkunle, 2012). For instance, texture and structure in soil physical characteristic group are strongly correlated. CEC and base saturation in fertility group are also correlated. Therefore, only one member of each quality group and the most limiting factor was used in each pedon. This follows the 'Liebig's law of the minimum' in agriculture, which states that crop yield is determined not by the total amount of resources available but by the most insufficient resource (limiting factor)(FAO, 1984; Ogunwale *et al.,* 2009). Consequently, the aggregate suitability in each pedon is determined by the overall lowest characteristic.

RESULTS AND DISCUSSION

Delineation of mapping units

The spatial (geo-referenced) data generated from the perimeter and profile pits of the farmland were input into the ArcGIS 10.3 software of Geographic Information System (GIS) application to produce the map of the project site (Figure 3). Following the flexible survey method, soil samples investigated consequent upon changes in physiographic features (slope, elevation and drainage) observed. These observable features formed the basis for delineating the landscape into three mapping units (UIN I – III) and representative profile pits were established in the mapping unit delineated (Figure. 3).

The farmland, covering a total land area of 100 ha was located between altitudes 162 and 212 m above sea level. Mapping unit UIN I covered 55.30 ha of the farmland and situated on elevation between 177 and 212 m above sea level with gently sloping terrain (3 %). Mapping unit UIN II was also located on gently sloping terrain (4 %) but with lower elevations (171 - 177 m above sea level) covering 17. 10 ha of the site. Contrarily, mapping unit UIN III occurred on nearly flat slope gradient (2 %) and altitudes between 162 and 171 m above sea level); and covered the land area of 17.60 ha (Figure3).

Characteristics of soils of the farmland

The morphological attributes of the farmland showed that mapping unit UIN I was situated on a gently sloping terrain (4-5 % slope gradient) while UIN II and III were located on very slightly sloping landscape (2-4 %). Mapping UIN I was relatively deep (115 cm) and moderately drained with no evidence of flooding (Table 3). The surface soil was weak and granular-structured across the surface and subsurface horizons. Consistence (moist) varied from firm to very firm in the subsurface and in wet condition; it was slightly sticky and slightly plastic overlying sticky and plastic subsoils.

Particle-size distribution (Table 4) showed that: mapping unit UIN I was characterized by sandy clay loam topsoil underlain by clayey subsoil; UIN II by loam overlying sandy clay loam and UIN III by sandy loam overlying clay loam. Sand fractions ranged from 22.9 –66.9 % with a decreasing trend down the depth whereas, the clay fractions progressively increased down the depth. Silt content was high (10 – 42 %) but did not show any definite pattern of distribution down the profile depth. The increased clay content observed down the pedal depth could be attributed to a marked pedogenic process of eluviation-illuviation consequent upon high and intense rainfall experienced in the area, leading to clay migration via the network of pores of the coarse texture of the upper horizons (Malagwi *et al.*, 2000). The weathering potential of the soils assessed by silt/clay ratio (0.57 – 2.12) indicated that the soils are still undergoing weathering (Table 4). This corroborate the findings of Van Wambeke (1962), Fasina *et al.* (2015) and Ajibola (2017) who reported that soils with silt/clay ratio more than 0.20 indicated soils with high degree of weathering.

The chemical properties of the soils (Table 5) across the mapping units showed that pH (H_2O) values ranged from 5.00 to 6.30. This pH range falls within strongly (subsurface) to slightly (surface) acid class (Chude *et al.*, 2011). Chude *et al.* (2011) had established pH range of 5.5 - 7.0 (slightly acid to neutral reaction) as optimal for overall satisfactory availability of plant nutrients. This implies that the soils of the study site were ideal for most crops to thrive as well as most nutrient elements especially; phosphorus will not be fixed and thus, will be readily available for absorption by plants in these slightly acid surface soils (Osodeke and Osondu, 2006). Organic carbon content of the surface soilranged from 1.82 to 3.66 %which is considered high based on soil nutrient interpretation of Chude *et al.* (2011) that soil organic carbon above2.0% is high for crop production. The subsoils were generally lower in organic carbon than the surface soil. The reasons for this may be attributed to higher litter falls on the surface soil and are the points where decomposition of organic materials takes place. Available P values (> 20 mg/kg) in the farmland are within the range recommended for most commonly cultivated crops (Enwezor *et al.*, 1989). The observed low level of bases in the soils could indicate leaching as a marked pedogenic process, resulting from the high gravel content in the area (Amusan *et al.*, 2006). The effective cation exchange capacity (ECEC) was relatively low with values ranging from 7.50 -11.70 $cmolkg^{-1}$. Nnaji *et al.* (2002) observed that, low effective cation exchange capacity of a soil could be because of clay type and content, high rainfall intensity as well as previous land use.

Soil classification

The soils on the three mapping units were classified according to the requirements of Soil Survey Staff(2014) and World Reference Base(2014). The evidence of argillic/argic horizons coupled with high base saturation classified the soils of mapping units UIN I and III at order level as Alfisols. The ustic soil moisture regime qualified the units as Ustalfs at suborder level and presence of ccontinuous concretionary layers (plinthite layers)placed them as Plinthustafs at Great group level and Typic Plinthustafs at Sub-group level in the USDA Soil Taxonomy. This correlated as Plinthic Lixisols under WRB classification system. However, the presence of cambic properties classified UIN II as Inceptisol. The ustic soil moisture regime qualified the unit as Ustept at suborder level and presence of ccontinuous concretionary layers (plinthite layers) placed it as Plinthustept at Great group level and Typic Plinthustafs at Sub-group level in the USDA Soil Taxonomy. The evidence of cambic and plinthic properties classified the soils as Plinthic Cambisols in the World Reference Base.

Land suitability assessment

The current suitability assessment of the farmlandfor cocoyam (Table 6) revealed that the entire farmland was optimum for cocoyam cultivation with reference to climate, soil drainage, effective soil depth (> 100 cm) and fertility. However, the undulating terrain with 4-5 % slope gradient has placed UIN 1 as marginally suitable (S3t). Similarly, soil depth (<75 cm), slope gradient (4 %) and fertility with respect to ECEC and available P were observed to limit the productivity of the soils to moderate suitability (S2stf) for cocoyam cultivation. Considering the fertility constraints (f) of the soils (pH and ECEC), the soils across the mapping units were moderately suitable (S2f) for mung bean production with additional poor drainage as limitation for UIN I (S2wf).

Generally, the suitability assessment showed that although certain qualities or characteristics such as mean annual temperature, relative humidity, rainfall, texture organic carbon, exchangeable K and base saturation are optimum for cocoyam and mung bean cultivation, there was no highly suitable (S1) mapping unit for the cultivation of the crops. About 33 ha of the farmland was marginally suitable (S3t) and the remaining 67 ha was moderately suitable for the production of cocoyam. Contrarily, the entire farmland was moderately suitable for mung bean cultivation (Table 7).

Conclusion and recommendation

The finding revealed shallow to moderately deep soil; moderately to well drained soils with sandy clay loam, underlain by clay. The soils were moderately to slightly acidic in reaction with relatively low values of effective cation exchange capacity. Organic carbon, total N, available P and base saturation were high whereas, exchangeable bases were low. The soils were classified as Typic Plinthustafs and Typic Plinthustteps (USDA) and Plinthic Lixisols and Plinthic Cambisols (WRB) respectively.

Suitability assessment of the farmland showed that UIN I was marginally suitable (S3t) whereas, UIN II and III were moderately suitable for cocoyam. However, all the units were moderately suitable (S2f) for mung bean cultivation. Identified constraints were low pH, fertility and effective soil depth.

Ridging across the slope would improve cocoyam performance in UIN I whereas more of phosphorous fertilizer would be needed in UIN II and III. Similarly, adequate drainage of UIN I and liming of the entire site would enhance optimum performance of mung bean in the area.

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Table 1: Rating of land use requirements for cocoyam

Land qualities	Land characteristics	High (>95%)	Moderate (85%)	Severe (60%)	Very Severe (<40%)
Climate(c)					
	Temperature (^0C)	21 – 27	25 – 30	30 – 35	>35
	Total rainfall (mm)	≥ 2000	1300 – 1999	1000 – 1299	< 1000
Fertility (f)	*Total N (%)*	0.10 – 0.06	0.03 - 0.05	0.01 – 0.02	<0.01
	Avail. P (mg/kg)	60 – 43	6 – 42	4 – 5	< 4
	Exch. K(cmol/kg)	0.15 – 0.05	0.03 - 0.04	0.01 - 0.02	< 0.01
	Organic Carbon (%)	2.10 – 1.26	0.8 - 1.25	0.4 - 0.7	< 0.4
	Soil pH	5 – 6.5	4.5 – 5.0	4.40 – 4.4	<4.0
	CEC (cmol/kg)	> 10	10 – 5	0 – 5	
	Base saturation (%)	> 60	40 – 60	20 – 39	< 20
Soil physical Characteristics(s)	*Texture*	Any	Any	Any	Any
	Soil depth (cm)	>75	50 – 75	30 - 50	<30
	Water table (cm)	Any	Any	Any	Any
Wetness (w)	*Drainage*	Any	Any	Any	Any
Topography(t)	*Slope (%)*	0- 2	2- 4	4- 6	> 6

Sources: Hackett (1984); Serem *et al.* (2008); Chukwu *et al.* (2014)

Table 2: Rating of land requirements for mung bean

Land qualities	Land characteristics	S1 (95-100%)	S2 (94-85%)	S3 (84-40%)	N (39 - 0%)
Climate (c)					
	Rainfall (mm)	350 – 600	600 – 1000	> 1000	
Humidity	Humidity (%)	40 – 75	36 – 42	30 - 36	
			75 – 90	> 90	< 30
Temperature	Temperatre (^{0}C)	30 - 24	24 – 20	20 - 15	<15 > 30
Wetness (w)	Drainage	Good	Moderate	Poor	V/poor
Soil Physical characteristics (s)					
	Texture	Loam	Clayey	Veryclayey	
	Depth (cm)	> 50	30 -50	< 30	
Topography					
	Slope (%)	0 – 10	11 – 20	21 - 35	> 35
Fertility (f)					
Nutrient availability	Soil pH	6.2 - 7.2	5 - 6.2	7.2 – 8	< 5 >8
Nutrient retention	CEC (cmol/kg)	> 10	10 – 5	0 – 5	
	Base Sat. (%)	> 70	60 – 70	40 - 60	20 – 40
	Exc. K (cmol/kg)	> 0.15	0.03 -0.08	0.02–0.03	< 0.02
	Avail. P. (mg/kg)	> 20	16 – 20	12 – 16	< 5
	Organic matter (%)	> 2	1 – 2	0.8 – 1	< 0.8

Sources: Montgosi, 2016; Oburuoga and Anyika 2012; Takeshi and Ruth 2015; Ogunwale *et al* 2009; Oluwatosin, 2005)

Table 3: Morphological characteristics of soil of the study area

Pedon	Horizon	Depth (cm)	Colour (moist)	Drainage	Slope (%)	Structure	Consistence Moist	Consistence Wet	Roots	Boundary
		Mapping Unit UIN I: 06^0 29. 29^1 N;07^0 33.68^1 E 184 m above sea level								
1	Ap	0–15	7.5YR 5/2(db)	Imperfect	5	w/granular	friable	ss/np	m/cm	Cs
	Btc	15–40	7.5YR 4/4(b)			w/granular	firm	s/sp	f/m	Cw
	Btcg	40–70	7.5YR 6/8 (ry)			w/granular	firm	s/p	f/fw	Cs
	BCcg	70–84	2.5YR 6/8 (lr)			w/granular	firm	s/p	-	-
2			**06^0 29.86^1 N; 07^0 33 .72^1 E 212 m above sea level**							
	Ap	0–29	7.5YR 5/2(b)	Imperfect	4	w/granular	friable	ns/np	m/cm	Cs
	Btcg	29–60	7.5YR 6/8 (ry)			w/granular	firm	s/sp	f/m	Gw
	BCcg	60–80	7.5YR 6/1 (lg)			w/granular	firm	s/p	f/cm	Cw
			06^0 29. 84^1 N;07^0 33.56^1 E 182 m above sea level							
3	Ap	0–27	10R 5/2 wr)	Well drained	4	w/granular	friable	ss/np	c/cm	Cs
	Btc1	27–60	10R 5/8 (r)			w/granular	friable	ss/sp	f/m	Cw
	Btc2	60–95	10R 6/8 (lr)			w/granular	firm	s/sp	f/fw	Gw
	BCc	95–115	10R 5/6 (lr)			w/granular	firm	s/sp	-	-
		Mapping Unit UIN II: 06^0 29.62^1 N; 07^0 33. 47^1 E 179 m above sea level								
4	Ap	0–4	10R 4/1 (drg)	Well drained	4	w/granular	friable	ss/np	c/cm	Cs
	Bt1	4-15	10R 3/1 (Dr)			m/granular	firm	s/sp	m/cm	Ds
	Bt2	15-35	10R 5/3 (wr)			m/sbk	firm	s/p	f/cm	Ds
	BC	35–60	10R 5/4 (wr)			s/sbk	firm	s/p	f/fw	-
5		**Mapping Unit UIN III: 06^0 29. 29^1 N;07^0 33.69^1 E 159 m above sea level**								
	Ap	0–7	10R 5/3 (wr)	Well drained	2	w/granular	friable	ns/np	c/cm	Gs
	Btc1	7–30	10R 5/4 (wr)			m/granular	firm	ns/np	m/cm	Ds
	Btc2	30–43	10R 6/4 (pr)			m/granular	firm	ss/np	f/cm	Ds
	BCg	43–60	7.5 YR 7/8 (ry)			m/sbk	firm	ss/sp	f/fw	-
6			**06^0 29.49^1 N; 07^0 33. 53^1 E 167 m above sea level.**							
	Apc	0-7	10R 5/2 (wr)	Well drained	2	w/granular	friable	ns/np	m/cm	Dw
	Btc	7-45	10R 5/4 (wr)			w/granular	friable	ns/np	f/cm	Dw
	BCc	45-80	10R 5/3 (r)			m/granular	firm	ss/sp	f/fw	

Key:Colour: b=brown, db=dark brown, ry=reddish yellow, lg=light gray, wr=weak red, r=red, lr=light red, drg=dark reddish gray, Dr=dusty red.**Structure**: w=weak, m=moderate, sbk=sub-angular blocky; **Consistence (wet):** ns/np=non sticky/non plastic, ss/np=slightly sticky/non plastic, s/sp=sticky/slightly plastic; **Pores/Roots**: c/m=coarse/many, c/cm=coarse/common, f/cm=fine/common, f/m=fine/many, m/cm=moderate/common, f/cm=fine/common, f/m=fine/many, c/m=coarse/many, f/fw=fine/few, vf/fw=very fine/few, f/vfw=fine/very few; **Boundary**:cs=clear and smooth, gw=gradual and wavy, cw=clear and wavy.

Table 4: Physical properties of the soils under different land use types

Pedon	Horizon	Depth (cm)	Sand %	Silt %	Clay %	Texture	Gravel %	SCR
	Mapping Unit UIN I: 06^0 29. 29^1 N;07^0 33.68^1 E 184 m above sea level							
1	Ap	0–15	66.9	12.0	21.1	SCL	61.5	0.57
	Btc	15–40	56.9	18.0	25.1	SCL	85.7	0.72
	Btcg	40–70	26.9	24.0	49.1	C	75.0	0.49
	BCcg	70–84	25.0	23.0	52.0	C	70.0	0.44
	06^0 29.86^1 N; 07^0 33 $.72^1$ E 212 m above sea level							
2	Ap	0–29	39.9	29.0	31.1	CL	80.0	0.93
	Btcg	29–60	34.9	22.0	43.1	C	69.0	0.51
	BCcg	60–80	22.9	22.0	55.1	C	75.0	0.40
	06^0 29. 84^1 N; 07^0 33.56^1 E 182 m above sea level							
3	Ap	0–27	28.9	42.0	29.1	L	40.0	1.44
	Btc1	27–60	26.9	24.0	49.1	C	71.4	0.49
	Btc2	60–95	26.9	18.0	55.1	C	67.1	0.33
	BCc	95–115	25.0	20.0	55.0	C	83.3	0.36
4	**Mapping Unit UIN II: 06^0 29.62^1 N; 07^0 33. 47^1 E 179 m above sea level**							
	Ap	0–4	38.9	42.0	23.1	L	55.6	1.81
	Bt1	4-15	46.9	30.0	19.1	L	47.1	1.57
	Bt2	15-35	48.9	32.0	15.1	L	39.4	2.12
	BC	35–60	47.0	32.0	21.0	SCL	90.1	1.52
5	**Mapping Unit UIN III: 06^0 29. 29^1 N;07^0 33.69^1 E 159 m above sea level**							
	Ap	0–7	74.9	10.0	15.1	SL	34.4	0.66
	Btc1	7–30	50.9	22.0	27.1	SCL	75.5	0.81
	Btc2	30–43	44.9	20.0	35.5	CL	68.3	0.56
	BCg	43–60	44.5	20.0	35.5	CL	75.5	0.56
6	**06^0 29.49^1 N; 07^0 33. 53^1 E 167 m above sea level.**							
	Apc	0-7	58.7	26.0	15.1	SL	34.4	1.72
	Btc	7-45	56.9	16.0	27.1	SCL	75.5	0.59
	BCc	45-80	38.9	22.0	39.1	CL	68.3	0.56

Key: SL = Sandy loam, SCL = Sandy clay loam, LS = Loamy sand, BD=bulk density, SCR=Silt-clay ratio; STDEV = Standard deviation, CV = Coefficient of variation, CV < 15= low variability, CV ≥15≤35=moderate variability, CV>35= high variability.

Table 5: Selected chemical properties of soils under different land use types

Horizon	Depth (cm)	pH (H_2O)	OC (%)	Av. P (mg/kg)	TN (%)	OM (%)	Ca^{+2}	Mg^{+2}	K^{+}	Na^{+}	ECEC	EA	BS (%)
							←	(cmol/kg)		→			
Mapping Unit UIN I (Pedon 1): 06^0 29. 29^1 N;07^0 33.68^1 E 184 m above sea level													
Ap	0–15	6.30	3.02	50.8	0.28	5.21	4.80	2.40	0.21	0.26	8.86	1.20	86.5
Btc	15–40	6.26	2.39	50.8	0.25	4.11	4.40	1.60	0.21	0.21	7.54	1.12	85.2
Btcg	40–70	5.10	1.48	28.5	0.16	2.55	6.80	2.80	0.24	0.19	11.00	0.96	91.20
BCcg	70–84	5.30	1.34	22.0	0.14	2.31	5.80	3.00	0.22	0.20	11.50	0.11	87.60
Pedon2: 06^0 29.86^1 N; 07^0 33 $.72^1$ E 212 m above sea level													
Ap	0–29	6.11	3.46	36.9	0.28	5.97	5.60	3.20	0.26	0.24	10.7	1.44	86.5
Btcg	29–60	5.60	1.34	26.5	0.14	2.32	6.40	3.60	0.24	0.15	11.7	1.28	89.1
BCcg	60–80	5.00	0.97	20.60	0.10	1.68	6.00	3.20	0.15	0.15	10.60	1.12	89.50
Pedon 3: 06^0 29. 84^1 N; 07^0 33.56^1 E 182 m above sea level													
Ap	0–27	5.76	2.32	51.2	0.21	4.00	4.80	2.80	0.23	0.20	8.75	0.72	91.7
Btc1	27–60	5.50	0.94	29.7	0.10	1.62	5.20	2.80	0.19	0.15	9.20	0.88	90.5
Btc2	60–95	5.59	0.64	27.5	0.09	1.10	4.40	2.40	0.11	0.10	8.44	1.44	83.00
BCc	95–115	5.50	0.54	25.0	0.10	0.93	4.00	2.00	0.12	0.10	7.5	1.10	81.60
Mapping Unit UIN II (Pedon 4): 06^0 29.62^1 N; 07^0 33. 47^1 E 179 m above sea level													
Ap	0–4	6.22	3.66	49.5	0.24	6.31	4.80	2.00	0.20	0.23	8.76	1.52	82.6
Bt1	4-15	5.96	2.05	50.8	0.21	3.53	4.00	2.40	0.15	0.18	8.66	1.92	77.8
Bt2	15-35	5.50	1.88	28.60	0.17	3.24	3.20	1.66	0.29	0.21	6.57	1.36	79.3
BC	35–60	5.10	1.34	25.50	0.15	2.10	2.80	1.60	0.15	0.15	6.16	1.36	73.5
Mapping Unit UIN III (Pedon 5): 06^0 29. 29^1 N;07^0 33.69^1 E 159 m above sea level													
Ap	0–7	5.80	1.81	40.0	0.16	3.13	5.20	2.50	0.17	0.17	9.38	1.04	88.9
Btc1	7–30	5.55	1.65	21.9	0.18	2.84	5.60	2.80	0.18	0.17	10.0	1.28	87.2
Btc2	30–43	5.84	1.45	32.00	0.13	2.49	6.00	3,20	0.19	0.17	11.8	2.24	81.00
BCg	43–60	5.50	1.35	25.00	0.10	2.33	5.00	2.30	0.18	0.16	10.50	2.10	80.00
Pedon 6: 06^0 29.49^1 N; 07^0 33. 53^1 E 167 m above sea level.													
Apc	0-7	5.80	3.49	55.3	0.20	6.02	4.80	2.40	0.21	0.22	8.83	1.20	86.4
Btc	7-45	5.37	2.02	44.0	0.18	3.48	5.20	2.80	0.23	0.19	9.44	1.04	89.0
BCc	45-80	5.65	0.94	26.2	0.08	1.62	5.60	3.20	0.15	0.12	9.95	0.85	91.1

Key: Avail. P=Available phosphorus, OC=Organic carbon, OM=Organic matter, EA=Exchangeable acidity, BS=Base saturation

Table 6: Suitability of the farmland for the cultivationcocoyam

	UIN I			UIN I	UIN III	
	Pedon					
Land qualities	1	2	3	4	5	6
Climate (c)						
Water availability (rainfall mm)	S1	S1	S1	S1	S1	S1
Humidity (%)	S1	S1	S1	S1	S1	S1
Temperature (^{0}C)	S1	S1	S1	S1	S1	S1
Wetness (w)						
Oxygen aavailability (drainage)	S1	S1	S1	S1	S1	S1
Soil Physical characteristics(s)						
Water retention capacity (texture)	S2	S2	S1	S1	S1	S1
Rooting condition (depth cm)	S1	S1	S1	S2	S2	S2
Topography (t)						
Slope (%)	S3	S3	S3	S2	S1	S1
Fertility (f)						
Nutrient availability (pH)	S1	S1	S1	S1	S1	S1
Nutrient retention (CEC cmol/kg)	S2	S2	S2	S2	S2	S2
Base Sat. (%)	S1	S1	S1	S1	S1	S1
Exc. K (cmol/kg)	S1	S1	S1	S1	S1	S1
Avail. P. (mg/kg)	S2	S2	S2	S2	S2	S2
Organic carbon (%)	S1	S1	S1	S1	S1	S1
Current aggregate Suitability	**S3t**	**S3t**	**S3t**	**S2stf**	**S2stf**	**S2stf**

Table 7: Suitability of the farmland for the cultivation mung bean

	UIN I			UIN II	UIN III	
	Pedon					
Land qualities	1	2	3	4	5	6
Climate (c)						
Water availability (rainfall mm)	S1	S1	S1	S1	S1	S1
Humidity (%)	S1	S1	S1	S1	S1	S1
Temperature (^{0}C)	S1	S1	S1	S1	S1	S1
Wetness (w)						
Oxygen aavailability (drainage)	S2	S2	S2	S1	S1	S1
Soil Physical characteristics(s)						
Water retention capacity (texture)	S1	S1	S1	S1	S1	S1
Rooting condition (depth cm)	S1	S1	S1	S1	S1	S1
Topography (t)						
Slope (%)	S1	S1	S1	S1	S1	S1
Fertility (f)						
Nutrient availability (pH)	S2	S2	S2	S2	S2	S2
Nutrient retention (CEC cmol/kg)	S2	S2	S2	S2	S2	S2
Base Sat. (%)	S1	S1	S1	S1	S1	S1
Exc. K (cmol/kg)	S1	S1	S1	S1	S1	S1
Avail. P. (mg/kg)	S1	S1	S1	S1	S1	S1
Organic carbon (%)	S1	S1	S1	S1	S1	S1
Currentaggregate suitability	**S2wf**	**S2wf**	**S2wf**	**S2f**	**S2f**	**S2f**

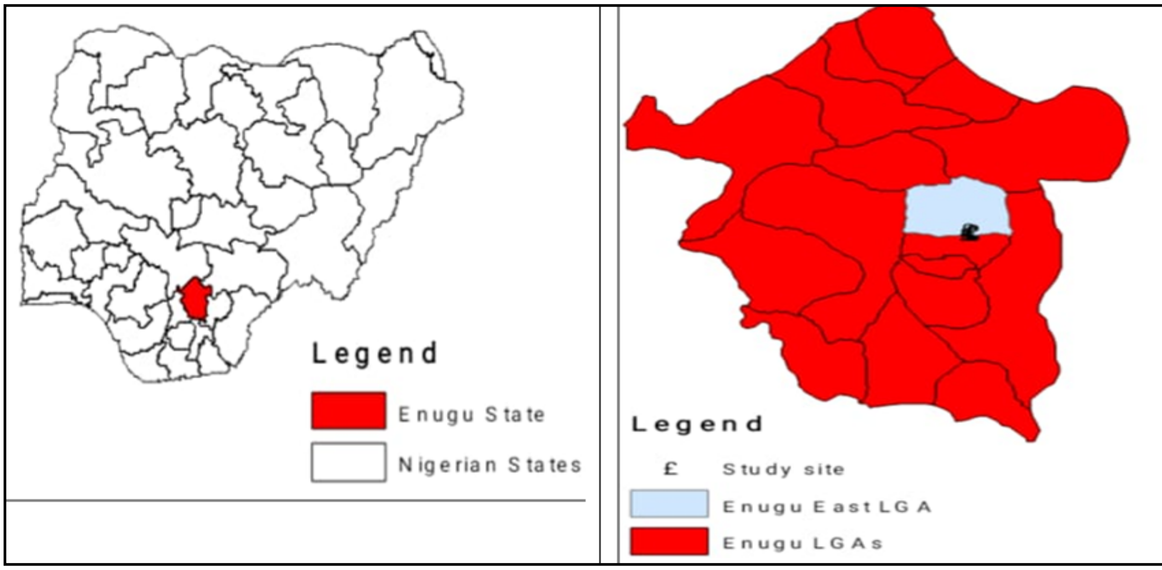

Fig. 1: Map of Enugu State showing the study area (Enugu East LGA) and the study site (Umuchigho Iji Nike)

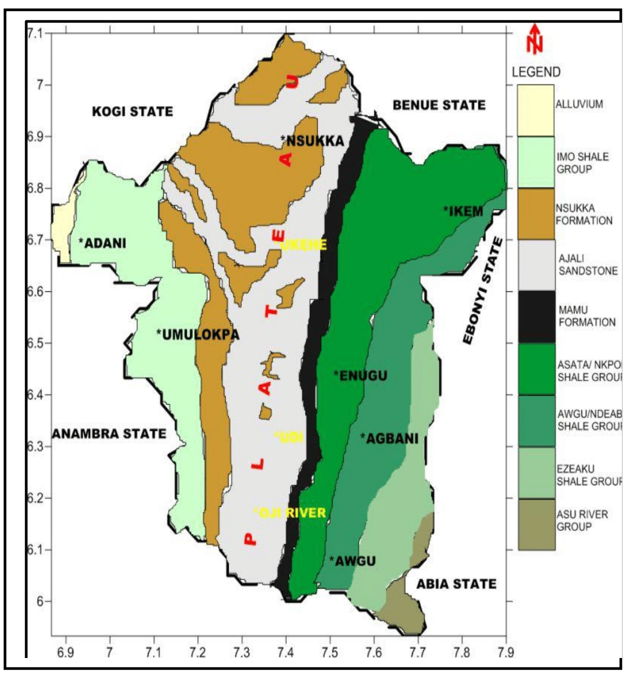

Fig.2: Geological map of Enugu State.
Source: Eze (2014)

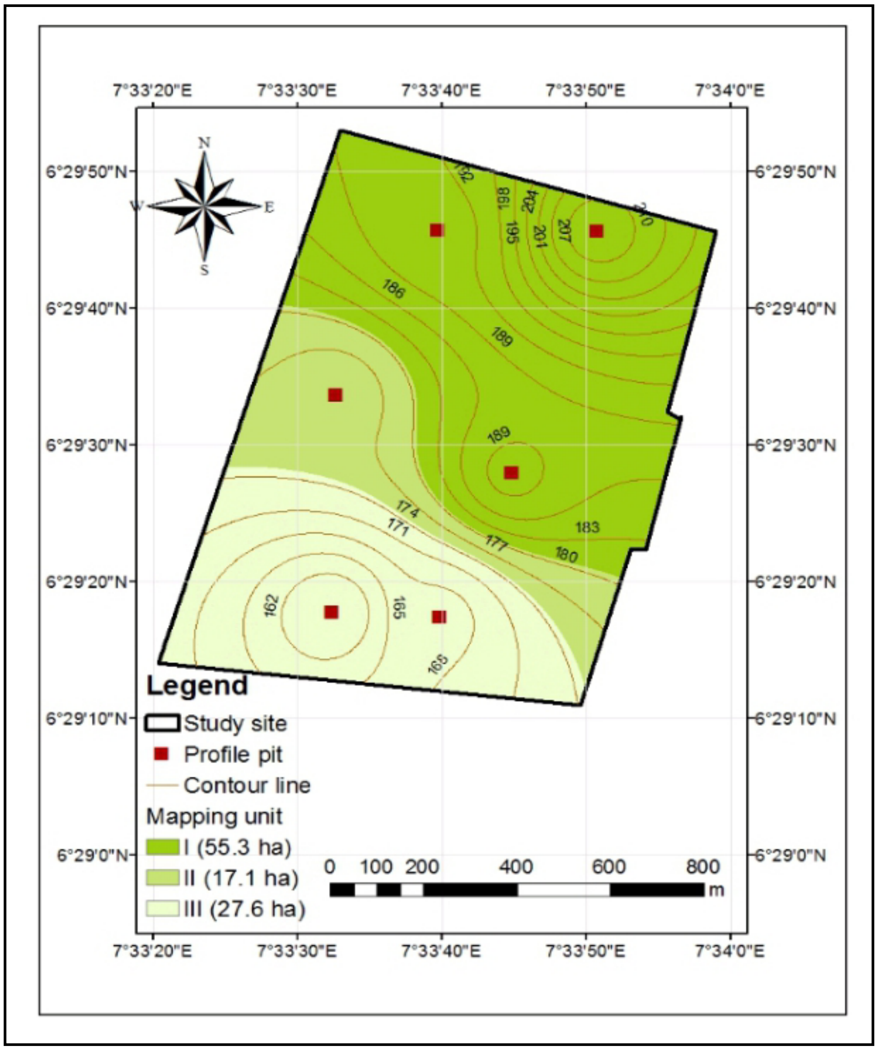

Fig.3: Delineated map of the study site (GIS)