LAND CAPABILITY CLASSIFICATION OF UNIVERSITY OF BENIN EXPERIMENTAL FARM.

F. E. Okunsebor and N. E. Ikator
Department of Soil Science and Land Management,
University of Benin, Nigeria.
faith.okunsebor@uniben.edu

ABSTRACT

Land users in most parts of the world are yet to come to terms with the fact that land capability assessment provides a ranking of the ability of an area to support a range of agricultural activities on a sustainable basis. The choice of landuse options have been based on mere discretion or local experience rather than good understanding of the physical characteristics of land, its inherent qualities and farm management practices that will support maximization of profits in agricultural investments in recent times. This study was conducted in University of Benin experimental farm to determine the capability of the land for crop production. The methodology involved a rigid grid soil survey at an intensive scale which produced two (2) modal classes; each modal class was represented by a pedon that was described, sampled and analysed appropriately using standard procedures. Results obtained from routine analysis revealed that sand was the dormant fraction of particle size (735 – 875 gkg^{-}1); silt ranged from 10 - 55 gkg^{-1}, clay values ranged from 70 – 286 gkg^{-1}; pH ranged from extremely acidic to strongly acidic, (4.1-5.2), organic carbon was low (2.0 – 9.80 gkg^{-1}). Exchangeable bases (Ca 0.69 – 0.86 cmolkg^{-1}; Mg 0.12 – 0.18 cmolkg^{-1}; Na 0.08 – 0.12 cmolkg^{-1}; K 0.16 – 0.21) were generally low when compared to their critical values. Land capability classification revealed that the study area qualified as class IV. The major constraint to crop production in the area is fertility (ECEC and Base Saturation) which is evident in the low pH values of the soils. Therefore, only arable crops can be grown in the study area. However, amendment with the right types and quantities of fertilizers as well as improved management practices would improve the capability status of the land.

Keywords: *Land, Land capability, Experimental farm, University of Benin*

INTRODUCTION

Land does not only refer to soil but also encompasses attributes such as geology, landforms, climate and hydrology, the plant cover and fauna, including insects and micro fauna associated with diseases (Cassidy *et al*., 2010); it serves as a fundamental natural resource upon which other resources are dependent. (Öztürk, 2017). However, land is unevenly distributed in terms of its qualities; hence it has limitations for various uses. Land capability classification (LCC) is a system of grouping soils primarily on the basis of their capability to produce common cultivated crops and pasture plants without deteriorating over a long period of time(NRCS, 2013). It refers the expression of all environmental parameters as applied to the biological potentials of a specific unit of land at a given time (AzfarMondal, 2019).

Land capability is based on the assessment of the biophysical characteristics of the land, the extent to which this will limit a particular type of landuse including the available technology for land management (Shyju and Kumaraswamy, 2018). The usefulness of land for agriculture, forest, built up area, tourism etc is assessed solely on the basis of physical environmental factors. Sustainable land utilization requires detailed information on appropriate technology, climatic condition, physical as well as chemical properties of the land in question (Sani *et al*., 2020). Land can be improved for a particular use through application of certain measures including certain kinds of landuses that can enhance sustained production (Raju, 2015).

Worldwide, the quantity of agricultural land is diminishing due to increase in human population accompanied by increase in economic needs; thus increasing the rate of land degradation and environmental pollution. People in most part of the world show less interest in land capability classification, even though the need for adequate knowledge on land capability classes in an agricultural area is quite necessary (James, 2014). Land capability classification enables the rational allocation of land to different land uses such as agricultural lands, wildlife, recreation, permanent grazing, woodland etc. Results obtained from land capability classification guide land users on choice of appropriate location and land use types.

University of Benin is located in the Southern part of Nigeria where high rainfall encourages high rate of leaching and erosion, thus, a study of this nature will guide the university community in the selection of appropriate sites for specific landuses. Moreover, the increasing rate of land degradation, urbanization and deforestation in this zone calls for immediate attention and information on land characteristics in order avoid wrong or inappropriate landuse choices. The objective of this study therefore, was to evaluate and predict the agricultural capability of the experimental farm and determine the area extent of each capability class.

Materials and Methods

Study Site

The study was conducted at the Faculty of Agriculture experimental farm, University of Benin, in Ovia North East Local Government Area of Edo state. The site lies within latitude 6° 24′ 0″N and 6° 24′ 10″N and longitude 5° 37′ 20″E and 5° 37′ 35″E.

The area falls within the rain forest vegetation zone of Nigeria (F.G.N. 2002) and is characterized by a tropical climate; it has two distinct climatic seasons, namely; the rainy and dry seasons. The dry season falls between November and February. The rainy season is between March and October with a 2-week break in August, commonly called the "August break". The soils are derived from recent Coastal Plain Sands known as Benin formation (unconsolidated sands and sandy clay) and alluvial deposits (Umweni, 2007). The topography is a terrace, with a height differentia of 1-4%.

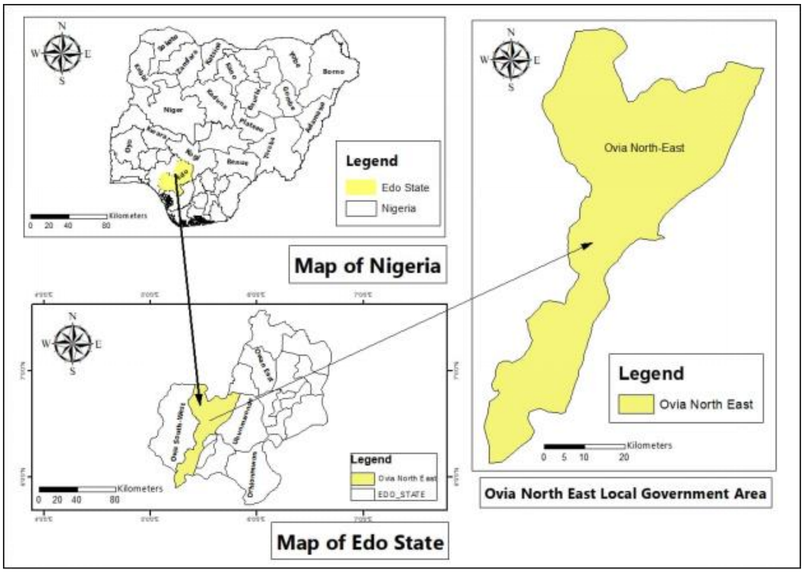

Figure 1: *Location map of study area*

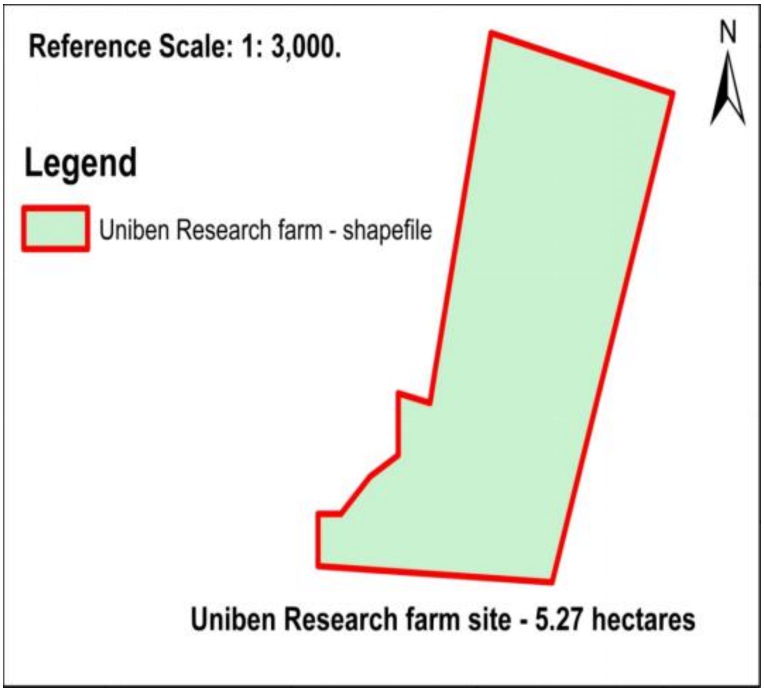

Figure 2: *Shape file of study Area*

Field Studies

The survey process was carried out using the rigid grid method at an intensive scale on the Land. Transverses were cut at intervals of 30 m apart, running in both vertical and horizontal directions. Soils were described by hand augering to a depth of 120 cm. At each observation point, information on soils such as soil drainage, soil colour, soil texture, soil structure (topsoil), and soil consistence were recorded. Areas with similar soil properties were put together to form the various modal classes; two (2) modal classes were delineated. Each modal class was represented by a pedon that was appropriately described according to FAO (2006). The samples were properly bagged, labelled and sent to the laboratory for analysis.

Laboratory Analysis

Soil samples collected from each horizon were air-dried and crushed to pass through a 2 mm sieve. The sieved samples were analysed using standard laboratory procedures. Determination of particle size distribution was done by the hydrometer method (Gee and Or, 2002) after the removal of organic matter with hydrogen peroxide and dispersion with sodium hexametaphosphate (International Institute for Tropical Agriculture, 1979). Soil textural classes were determined using textural triangle (Soil survey staff, 2003). Soil pH was determined with pH meter using a glass electrode in soil and water suspension of 1:1 (Mclean, 1982).Organic C was determined by dichromate wet oxidation method of Walkley and Black (Page, 1982).Available phosphorus was determined according to Bray1method (Olsen and Sommers, 1982). Total Nitrogen was determined by macro-Kjedhal method (Bremner, 1996). Exchangeable cations (Na, K, Ca, and Mg) were determined by extraction with neutral normal ammonium acetate (NH4OAC at pH 7.0) method, Na and K were determined by flame photometer, while Ca and Mg were determined by atomic absorption spectrophotometer (Thomas, 1982).Exchangeable Acidity determination was done by titration method (Anderson and Ingram, 1993). Effective Cation Exchange Capacity (ECEC) was obtained by the summation of exchangeable bases and exchangeable acidity (Tan, 1996). Calculation of base saturation was done by dividing the sum of exchangeable bases (Na, K, Ca and Mg) by ECEC and multiplying the quotient by 100.

Land Capability Assessment

Land capability assessment was done using the qualitative method according to the FAO (2007) frame work for rain fed agriculture and using appropriate guidelines provided by USDA (1961). Pedons were placed in capability classes by comparing their land qualities and characteristics with the requirements gotten from the guideline. Classes were based on both degree and number of limitations affecting kind of use, risks of soil damage if mismanaged, needs for soil management, and risks of crop failure. The aggregate capability class of a Pedon is indicated by the most limiting characteristics of that Pedon and this was carried out according to the principle of the law of the minimum which states that performance is always determined by the least favourable factor (FAO, 1984). The capability class which shows the most severe limitation after evaluation using the appropriate guideline for the different mapping units became the aggregate capability class.

The capability classes are:

Class 1 soils have slight limitations that restrict their use.

Class 2 soils have moderate limitations that restrict the choice of crop or that require moderate conservation practices.

Class 3 soils have severe limitations that restrict the choice of plants or

that require special conservation practices, or both.
Class 4 soils have very severe limitations that restrict the choice of plants or that require very careful management, or both.
Class 5 soils are subject to little or no erosion but have other limitations, impractical to remove, that restrict their use mainly to pasture, rangeland, forestland or wild life habitat.
Class 6 soils have severe limitations that make them generally unsuitable for cultivation and that restrict their use mainly to pasture, rangeland, forestland, or wildlife habitat.
Class 7 soils have very severe limitations that make them unsuitable for cultivation and that restrict their use mainly to grazing, forestland, or wildlife habitat.
Class 8 soils and miscellaneous areas have limitations that preclude commercial plant production and that restrict their use to recreational purpose, wildlife habitat, watershed, or esthetic purposes.

Results and Discussion

Morphologically, soil colour was dark reddish brown (2.5YR3/3, 5YR3/3) in A horizon, but ranged from dark reddish brown (2.5YR3/3), reddish brown to red (2.5YR4/4, 2.5YR4/6 and 2.5YR4/8). Soil colour may have been by climate (rainfall amount), organic matter content and drainage (Osujieke, 2020). The study area was deep (>150 cm) according to the rating of Soil Survey Staff (2014). Generally, the soils were light textured (S - LS) in A horizon but medium textured (SL – SCL) in B horizon. Root abundance was fine (fine common in pedon 1; Fine many/Medium coarse in pedon 2) in A horizon but ranged from medium to very few in B horizon. The concentration of roots in surface horizons could be attributed to rooting pattern of plants present in the study area. Structure for A was granular in pedon 1 but fine sub-angular blocky in pedon 2; however, it was sub-angular blocky in B horizon.

Results from physical and chemical analysis revealed that sand was the dominant fraction of particle size (700 - 850 gkg^{-1}); silt ranged from 10 - 55 gkg^{-1}, clay ranged from 70 - 286 gkg^{-1}. the dominance of sand fraction may be attributed to the parent material from which the soils were derived (coastal plain sand) while the low silt fraction may be as a result of the degree of weathering in the study area (Okunsebor, 2023; Ahukaemere *et al*. 2017). pH increased irregularly down the profiles with values of 4.5 (in pedon 1) and 4.3 (pedon 2) in surface horizon, but ranged from extremely acidic (4.1 – 4.7 in pedon 1) to extremely acidic – strongly acidic (4.4 – 5.2 in pedon 2) in subsurface horizons. This is in line with the findings of Agbogun *et al*. (2021).

Increase in pH values may be attributed to the nature of treatments that have been applied on soils over the years. Total Nitrogen for pedon 1 was above the critical limit of 0.15% (0.20 – 0.64%) (FMANR, 1999; Chude, 2011), except for horizon BW2 (0.10%); pedon 2 was below the critical limit (0.09 – 0.12) in most horizons, except in Horizons Ap and Bt1 (0.16 – 0.62%). Organic carbon was generally low in the study area, when compared with the critical value (< 4%) according to the ratings of FDALR, (1985). It decreased down with profiles with values ranging from 9.80 gkg^{-1} (in pedon 1) and 9.38 gkg^{-1} (in pedon 2) in surface horizon, to 2.00 – 5.78 gkg^{-1} (pedon 1), and 2.00 – 3.05 gkg^{-1} in subsurface horizons. Exchangeable bases (Ca, 0.69 – 0.86 $cmolkg^{-1}$; Mg, 0.12 – 0.18 $cmolkg^{-1}$; Na, 0.08 – 0.12 $cmolkg^{-1}$; K, 0.16 – 0.21) were generally low when compared to their critical values (Ca - 4 $cmolkg^{-1}$, Mg - 0.5 $cmolkg^{-1}$, Na and K – 0.2 $cmolkg^{-1}$; FAO, 1976; Chude *et al*. 2011). However, potassium was high in surface horizons (0.20 $cmolkg^{-1}$ in pedon 1; 0.21 $cmolkg^{-1}$ in pedon 2)

Land Capability Classification

Land characteristics were assessed according to the guideline provided by USDA (1961). The topography was generally flat in pedon 1 (1-2%), thus placing the pedon it as class (I); but gentle slope in pedon 2 (2- 4%), placing the pedon in class (II); slope is a major characteristics in land capability ratings (Oluwatosin *et al*., 2006) on the basis of wetness, the study area had no limitations in flooding and drainage conditions; therefore, it qualified as class (I). it was observed from the soil physical characteristics that surface texture was Sand, which according to the guideline is Class (II), while sub-surface texture ranged from Loamy Sand (pedon 1) / Sandy Loam (pedon 2) to Sandy clay loam; thus, rating both pedons as Class (III). Soil depth was greater than 1.5 m in both pedons, rating the study area as Class (I), which suggests that the study area may be suitable for a wide range of plants such as tree-crops and pastures. Fertility characteristics indicated that ECEC had values (4.43-4.56$cmolkg^{-1}$) that were < 16 (cmol/kg); this qualified the study area as class (IV). Base saturation for both pedons was rated class (IV) because the values were > 15% but < 35% (21.71-26.96%). Organic carbon at 0-15cm was 9.80 gkg^{-1} (pedon 1) and 9.38 gkg^{-1} (pedon 2), it was rated as class (III).

The aggregate capability class is according to the law of minimum which states that performance is determined by the least favourable characteristic or factor (FAO, 1984). By this principle, the least favoured characteristics were ECEC and Base saturation. Therefore, on aggregate rating, land capability classification the entire study area was class IV; the soils in this capability class (class IV) have very severe limitations that restrict the choice of plants and require very careful management (USDA, 1961). These soils may be well suited to only one or two of the common crops or the harvest produced may be low in relation to inputs over a long period of time. Landuse for cultivated crops is limited as a result of the effects of fertility characteristics.

Table 1: Summary of Land Capability Assessment

LAND CHARACTERISTICS	**CAPABILITY CLASS**	
	PEDON 1	**PEDON 2**
Slope (%)	1-2 (I)	2-4 (II)
Surface texture	S (III)	S (III)
Sub-surface texture	SCL (II)	SCL (II)
Soil Depth	>1.5 (I)	>1.5 (I)
Drainage	Good (I)	Good (I)
Flooding	No(Fo) (I)	No(Fo) (I)
ECEC(Cmol/kg)	4.20-4.63 (IV)	4.43-4.56 (IV)
Base saturation (%)	23.21-29.80 (IV)	21.71-26.96 (IV)
Organic carbon (g/kg) (0-15cm)	9.38 (III)	9.80 (III)
Aggregate class	IV	IV
Area covered (ha)	3.31	2.16
% coverage	59.01	40.99

Table 2: Guideline for Land Capability Assessment

CHARACTERISTICS	CLASS I	CLASS II	CLASS III	CLASS IV	CLASS V	CLASS VI	CLASS VII	CLASS VIII
TOPOGRAHY								
Slope(%)	<2	<6	<12	<25	<25	<25	<55	<55
WETNESS(W)								
Flooding	No (Fo)	No (Fo)	No (Fo)	No (Fo) to slight	No to severe	No to severe	No to very severe	No to very severe

Drainage (i)	Good	Moderate or better	Somewhat imperfect or better	Moderate or better	Poor or better	Poor or better	Very poor or better	Very poor or better
PHYSICAL CONDITIONS (s)								
Surface Texture	SL to Co	LfS to Co-60s	fS to C-60v	cS to C+60v	cS to Cm	cS to Cm	cS to Cm	cS to Cm
Surface coarse fragments(vol. %)	None	<15	<35	<55	<55	<55	<75	<75
Surface stoniness(%)	None	<0.01	<0.1	<0.3	<15	<15	<75	<75
Rockiness (%)	None	<2	<10	<25	<50	<50	<75	<75
Sub-surface texture	L to C-60	SCL to C-60v	LfS to C+60v	fS to C-60v	cS to Cm	cS to Cm	cS to Cm	cS to Cm
Sub-surface coarse fragments(vol. %)	<15	<35	<55	<75	<75	<75	<75	<75
Soil Depth (m)	>1.5	>1.0	>0.50	>0.25	>0.25	>0.25	>0.10	<>0.10
FERTILITY (f)								
Apparent ECEC (cmol/kg)	>16	<>16	<>16	Any	Any	Any	Any	Any
Base saturation	>80	>50	>35	>15	>15	>15	<>15	<>15
O.C(g/kg)(0-15cm)	>15	>10	>6	>4	>4	>4	<>4	<>4

Source: USDA (1961).

Conclusion

Land capability rating of the study area revealed the presence of only one capability class in the study area. Generally, the soils are acidic. They are well drained with no problem of flooding in the area; though these characteristics are evident, fertility (ECEC and base saturation) is a major constraint. Based on the findings of this study, only arable crops can be grown in the study area. However, to achieve sustained increase in food production on a long term basis, there is need for an integrated soil management package involving application of the right types and quantity of inorganic fertilizer, animal manure, crop residues and better cultural practices in the area.

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SOME PHYSICAL AND CHEMICAL PROPERTIES OF THE SOILS

PEDON	DEPTH (cm)	HORIZON DESIG.	EC (ds/m)	PH	T.N gkg⁻¹	T.O.C gkg⁻¹	AV. P mgkg⁻¹	K cmolkg⁻¹	Ca	Mg	Na	H^+	Al^{3+}	CEC	ECEC	BS %	ECEC Clay %	Clay gkg⁻¹	Sand	Silt	TC
		06.40134°N, 005.62547°E																			
1	0-22	Ap	21.5	4.5	0.64	9.80	8.56	0.20	0.70	0.14	0.11	2.28	1.08	3.43	4.51	25.49	46.02	850	52	98	S
	22-43	Bw	22.0	4.1	0.32	5.78	7.80	0.18	0.60	0.12	0.09	2.40	1.17	3.39	4.56	21.71	34.29	830	37	133	LS
	43-68	Bw2	22.8	4.4	0.10	2.00	4.86	0.14	0.67	0.14	0.10	2.30	1.08	3.35	4.43	23.70	29.53	834	16	150	LS
	68-108	Bhw1	25.8	4.6	0.20	3.10	5.40	0.18	0.73	0.16	0.10	2.25	1.08	3.42	4.50	26.00	20.83	770	14	216	SCL
	108-188	Bhw2	32.4	4.7	0.20	3.20	5.05	0.18	0.75	0.16	0.11	2.20	1.05	3.40	4.45	26.96	15.56	700	14	286	SCL
	06.40060°N, 005.62583°E																				
2	0-10	Ap	20.6	4.3	0.62	9.38	8.50	0.21	0.86	0.18	0.13	2.10	1.15	3.48	4.63	29.80	66.14	875	55	70	S
	10-35	Bt1	28.4	4.4	0.16	3.05	5.30	0.14	0.70	0.16	0.10	2.00	1.10	3.10	4.20	26.19	23.33	790	30	180	SL
	35-73	Bt2	35.3	4.5	0.12	3.01	4.62	0.13	0.69	0.14	0.08	2.26	1.18	3.30	4.48	23.21	18.44	735	22	243	SCL
	73-118	Bt3	30.3	5.2	0.09	2.05	4.95	0.18	0.78	0.16	0.12	2.17	1.00	3.41	4.41	28.11	19.95	753	26	221	SCL
	118-188	Bt4	36.7	4.5	0.10	2.00	4.58	0.16	0.70	0.13	0.10	2.25	1.10	3.34	4.44	24.54	17.90	742	10	248	SCL