

FERTILITY CAPABILITY CLASSIFICATION FOR AGRICULTURAL LAND USE PLANNING IN THE BEACH SANDS AREA OF AKWA IBOM STATE, NIGERIA

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ABSTRACT

Soil survey and fertility capability classification (FCC) were carried out in an area mostly underlain by the beach ridge sands (BRS) parent material in Akwa Ibom State, Nigeria. The study applied the FCC in agricultural land use planning for efficient land management and optimal agricultural productivity of the beach soils. Field and laboratory data were obtained from 40 pedons located across eight Local Government Areas on the BRS parent material. From the results of field and laboratory studies, 11 FCC units were identified in the area. Based on similarities in certain soil profile characteristics, the 11 FCC units were grouped into four agro-ecological units (AEUs): (i) poorly drained FCC units with sandy topsoil over sandy subsoil, grouped to form AEU-A, covered 65.00% of study area; (ii) well drained FCC units with sandy topsoil over sandy subsoil, formed AEU-B and covered 22.50% of study area; (iii) poorly drained FCC units with sandy topsoil over loamy subsoil or loamy top- and sub- soils, formed AEU-C and covered 7.50% of study area; (iv) well drained FCC units with sandy topsoil over loamy subsoil, which formed AEU-D, occupied 5.00% of study area. The result of this study has shown that FCC can be employed as a simple but efficient tool in agricultural land use planning. Major soil profile characteristics used to differentiate land units within the beach sands area of Akwa Ibom State are drainage and texture.

Key words: beach soils, parent material, profile characteristics, agricultural units, land management

INTRODUCTION

Soil characteristics and ability to supply required plant nutrients are largely determined by parent materials as influenced by climate, topography and the general agricultural land use and management patterns (Ibia and Udo, 2009; Udoh *et al.*, 2013a). Soils derived from the beach ridge sands, just like other acid sands of southern Nigeria, are fragile, acidic and low in native fertility (Udo and Sobulo, 1981). In Akwa Ibom State, the beach ridge sands occupy the space from the shoreline, forming a wide sandy and surf beach to about 10 km inland. It occupies about 560 km² within the Qua Iboe River Basin (Tahal Consultants, 1982; Unyienyin, 2010).

The current shortage of food and increasing food requirements for the rapidly expanding population necessitate that marginal lands such as the beach ridges, hitherto left under-utilized, be brought under intensive agricultural use. This is particularly needed in Akwa Ibom State where crude oil spillage is a perennial problem often with long-lasting effects in the agricultural soils (Umoren *et al.*, 2019). However, available data on beach ridge soils are insufficient to guide systematic planning for the present and future use of the soils for agriculture. A clear understanding and appropriate classification of the various soil types based on their differentiating features is essential for efficient land use and increased sustainable productivity of beach soils.

The fertility capability classification (FCC) system is a suitable framework for agronomy soil taxonomy. It is acceptable to both pedologists and agronomists (Lin, 1989; Udoh *et al.*, 2013b). Udo *et al.* (2009a) had earlier used the FCC to evaluate the fertility status of some wetland soils in Akwa Ibom State. The FCC units are groups of soils with similar kinds of problems and requirements for agronomic management of the physical and chemical properties of soils in a particular location. The study carried out FCC of beach sands area of Akwa Ibom State, using the FCC units as basis for efficient and sustainable agricultural land use planning.

MATERIALS AND METHODS

Study Site

The study was conducted in the southern part of Akwa Ibom State, Nigeria; comprising mainly coastal areas of Ikot Abasi, eastern Obolo, Esit Eket, Eket, Mkpat Enin, Onna, Ibeno and Mbo Local Government Areas (LGAs). The area is located on the map within latitudes 4° 35' and 4° 40' N and between longitudes 7° 30' and 8° 15' E (Figure 1).

Field Work and Laboratory Analysis

Based on actual field information gathered from reconnaissance surveys a total of 40 pedons were sited across the eight afore-listed LGAs representing the beach ridge soils in the State. All the profile pits were geo-referenced and described as outlined by

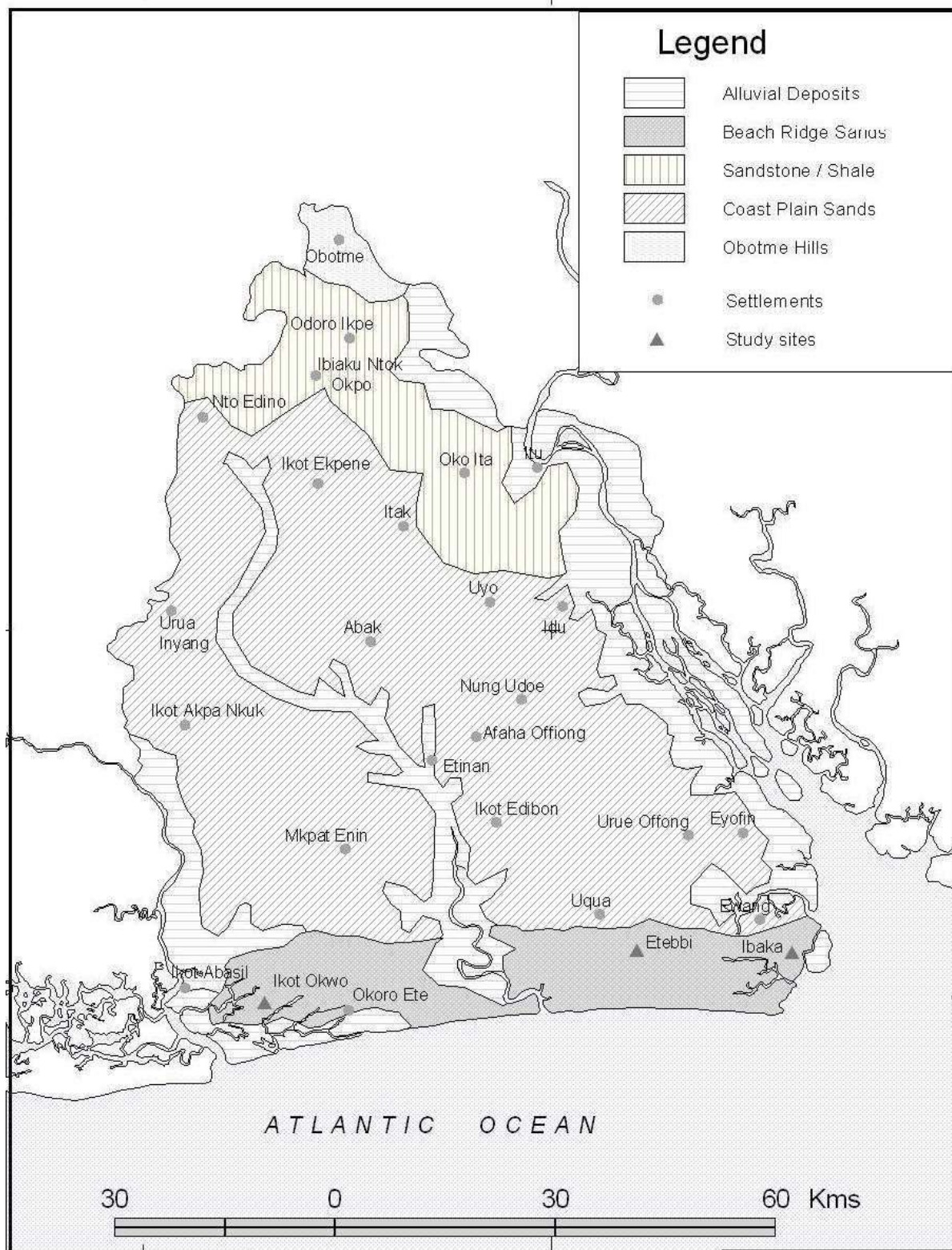


Figure 1: Map of Akwa Ibom State showing the beach ridge sands and other parent materials

FAO (2006). Soil samples were collected from the identified genetic horizons and prepared for laboratory analysis according to standard procedures (IITA, 1979; Udo and Ogunwale, 1986; Udo *et al.*, 2009b). Parameters analyzed included; particle size distribution, soil reaction (pH), electrical conductivity, organic carbon, total nitrogen

available phosphorus, exchangeable bases and exchangeable acidity. Effective cation exchange capacity (ECEC) was determined as the summation of exchangeable cations (Ca, Mg, K, Na) and exchangeable acidity (Al^{3+} , H^+). Base saturation was determined as a sum of exchangeable basic cations divided by ECEC and multiplied by 100.

Fertility Capability Classification

Data obtained from field morphological study and laboratory analysis of soil samples from the 40 pedons were used for FCCs. The conversion data used in evaluating the soils were as outlined by Sanchez *et al.* (1982). The system consists of three categorical levels; type (texture of plough layer or top 20.00 cm), substrata type (texture of subsoils), and modifiers (soil properties or conditions which act as constraints to crop performance). Class designations from the three levels were combined to form a FCC unit. The FCC units of the representative 40 pedons in the study area are shown in Tables 1 and 2.

Agricultural Land Use Planning

For the purpose of developing an agricultural land use plan for the area of study, similar FCC units were grouped together to form an agro-ecological unit (AEU). Each AEU contained soils with similar

kinds of problems that require particular agronomic management of their physical and chemical properties for optimum land productivity.

RESULTS AND DISCUSSION

Fertility Capability Classification of Soils in the Study Area

The FCC of soils derived from the breach ridge sands parent material in Akwa Ibom State is presented in Table 1, while the brief interpretation of each FCC unit is presented in Table 2. The result shows that the 40 pedons identified in the study area were classified into 11 FCC units. Seven of the 11 units had sandy top- and sub-soils (S) as their type and substrata type; two units had sandy topsoil and loamy subsoil (SL); while each unit had loamy top- and sub-soil (L) and loamy topsoil or sandy subsoil (LS), respectively. Irrespective of the type and substrata type, all the 40 pedons were acidic

Table 1: Fertility capability classification (FCC) of pedons in the study area

Pedon	Type ¹	Substrata type ²	Condition modifiers ³													FCC unit
			g	d	k	e	a	h	b	i	x	v	s	n	c	
Eastern Obolo LGA																
1	S	S	+	-	+	-	-	+	-	-	-	-	-	-	-	Sgkh
2	S	S	+	-	+	-	-	-	+	-	-	-	-	-	-	Sgkh
3	S	S	+	-	+	-	-	-	+	-	-	-	-	-	-	Sgkh
4	S	S	+	-	+	-	-	-	+	-	-	-	-	-	-	Sgkh
Eket LGA																
5	S	S	+	-	-	-	-	-	+	-	-	-	-	-	-	Sgh
6	S	S	+	-	+	-	-	-	+	-	-	-	-	-	-	Sgkh
7	L	L	+	-	-	-	-	-	+	-	-	-	-	-	-	Lgh
Esit Eket LGA																
8	S	L	-	-	+	-	-	-	+	-	-	-	-	-	-	SLkh
9	S	L	-	-	+	-	-	-	+	-	-	-	-	-	-	SLkh
10	S	S	+	-	+	-	-	-	+	-	-	-	-	-	-	Sgkh
11	S	S	-	-	+	+	+	-	+	-	-	-	-	-	-	Skeh
12	S	S	+	-	+	+	+	-	+	-	-	-	-	-	-	Sgkeh
13	S	S	+	-	+	+	+	-	+	-	-	-	-	-	-	Sgkeh
14	S	S	+	-	+	+	+	-	+	-	-	-	-	-	-	Sgkeh
15	S	S	+	-	+	+	+	-	+	-	-	-	-	-	-	Sgkeh
16	S	S	+	-	+	+	+	-	+	-	-	-	-	-	-	Sgkeh
17	S	S	+	-	+	+	+	-	+	-	-	-	-	-	-	Sgkeh
18	S	S	-	-	+	+	+	-	+	-	-	-	-	-	-	Sgkeh
Ibena LGA																
19	S	S	+	-	+	+	+	-	+	-	-	-	-	-	-	Sgkeh
20	S	S	+	-	+	+	+	-	+	-	-	-	-	-	-	Sgkeh
21	S	S	-	-	-	-	-	-	+	-	-	-	-	-	-	Sh
Ikot Abasi																
22	L	S	+	-	+	-	-	-	+	-	-	-	-	-	-	LSgkh
23	S	S	+	-	-	-	-	-	+	-	-	-	-	-	-	Sgkh
24	L	S	+	-	-	-	-	-	+	-	-	-	-	-	-	LSgh
25	S	S	+	-	+	+	+	-	+	-	-	-	-	-	-	Sgkeh
26	S	S	+	-	+	+	+	-	+	-	-	-	-	-	-	Sgkeh
27	S	S	+	-	+	+	+	-	+	-	-	-	-	-	-	Sgkeh
28	S	S	+	-	+	+	+	-	+	-	-	-	-	-	-	Sgkeh
Mbo LGA																
29	S	S	-	-	+	+	+	-	+	-	-	-	-	-	-	Skeh
30	S	S	-	-	+	+	+	-	+	-	-	-	-	-	-	Skeh
31	S	S	-	-	+	+	+	-	+	-	-	-	-	-	-	Skeh
32	S	S	+	-	+	+	+	-	+	-	-	-	-	-	-	Sgkeh
33	S	S	+	-	+	+	+	-	+	-	-	-	-	-	-	Sgkeh
Mkpat Enin LGA																
34	S	S	+	-	+	-	-	-	+	-	-	-	-	-	-	Sgkh
35	S	L	+	-	+	-	-	-	+	-	-	-	-	-	-	SLgkh
Onna LGA																
36	S	S	-	-	+	-	-	-	+	-	-	-	-	-	-	Skh
37	S	S	+	-	+	-	-	-	+	-	-	-	-	-	-	Sgkh
38	S	S	+	-	+	-	-	-	+	-	-	-	-	-	-	Sgkh
39	S	S	-	-	+	-	-	-	+	-	-	-	-	-	-	Skh
40	S	S	-	-	+	-	-	-	+	-	-	-	-	-	-	Skh

After Sanchez *et al.* (1982). ¹texture of topsoil (20 cm), ²texture of subsoil, ³soil properties which are constraints to crop production.

S - sandy, L - loamy, g - gleying, d - dry, k - low K reserves, e - low cation exchange capacity (CEC), a - aluminum toxicity, h - acidic, b - basic, i - high P fixation by iron, x - X-ray amorphous, v - Vertisol, s - salinity, n - nitric, c - cat clay; LGA - local government area

Table 2: Brief interpretation of the fertility capability classification (FCC) units

FCC unit	Brief interpretation	Area occupied (%)
Sgkeh	Soils characterized by sandy topsoil and sandy subsoil (S). Major constraints to crop production are poor drainage and wetness i.e., gleying condition (g), low potassium (K) reserves (k), low effective cation exchange capacity (ECEC) (e), and acidic reaction (h).	32.50
Sgkh	Soils with sandy top- and sub-soil profiles. Major constraints to crop production are gleying or poor drainage (g), low K reserves (k) and acidic reaction (h).	25.00
Skeh	Soils characterized by sandy topsoil and sandy subsoil. Fertility constraints are low K reserves (k), low ECEC (e) and soil acidity (h).	12.50
Skh	Soils characterized by sandy topsoil/subsoil with low K (k) and soil acidity (h) as crop production constraints.	7.50
Sgh	Soils characterized by sandy topsoil and sandy subsoil. Major constraints to crop production are poor drainage or gleying (g) and soil acidity (h).	5.00
SLkh	Soils characterized by sandy topsoil (S) and loamy subsoil (L). Major constraints to crop production are low K reserves (k) and soil acidity (h).	5.00
SLgkh	Soils characterized by sandy topsoil (S) and loamy subsoil (L), with poor drainage/gleying (g), low K reserves (k) and acidic reaction (h).	2.50
Lgh	Soils characterized by loamy topsoil and loamy subsoil (L), with gleying or poor drainage (g) and acidic reaction (h) as constraints to crop production.	2.50
LSgh	Soils characterized by loamy topsoil (L) and sandy subsoil (S). Constraints to crop production are poor drainage or gleying (g) and acidic reaction (h).	2.50
Sgeh	Soils with sandy top- and sub- soils. Major fertility constraints are poor drainage or gleying (g), low ECEC (e), and soil acidity (h).	2.50
Sh	Soils characterized by sandy top- and sub- soils (S). Major constraint to crop production is acidic reaction.	2.50

in reaction (h). Furthermore, 29 of the sampled pedons had poor drainage or gleying conditions (g) as significant constraint to crop production. Thirty-four (34) pedons had low potassium (K) reserves (k), while 19 pedons had low ECEC (e) as constraints to crop production. Brief interpretations of the 11 FCC units are outlined in Table 2. Present findings have shown that FCC is efficient in grouping soils with similar kinds of problems and requirements for agronomic management of the physical and chemical properties of beach soils in Akwa Ibom State, Nigeria. This result collaborates with similar reports from previous investigations (Sanchez *et al.*, 1982; Lin, 1989; Udoh *et al.*, 2013a).

Agricultural Land Use Plan for the Study Area

From the fertility capability classifications of soils in the study area, an agricultural land use plan has been developed for the study area. This is for the purpose of efficient land use and management for optimal and sustainable land productivity. Based on closed similarities in certain profile characteristics among the 11 FCC units (Tables 1 and 2), the area of study was zoned into the four agro-ecological units (AEUs) outlined below. The most important profile characteristics used as the criteria for the creation of the AEUs are soil texture and drainage.

Agro-ecological unit A (AEU-A)

This comprised all areas with FCC units characterized by sandy top and subsoils with poor drainage as a general constraint to crop production. The FCC units in Table 2 that make up AEU-A are Sgkeh (32.50%), Sgkh (25.00%), Sgh (5.00%) and Sgeh (2.50%). The total land area occupied by AEU-A is 65.00% of the study area (Figure 2).

Agro-ecological unit B (AEU-B)

The unit comprises FCC units which are also characterized by profiles with sandy top and sub-soils like AEU-A, but unlike AEU-A, they are well drained profiles. The FCC units comprising AEU-B (Table 2) are Skeh (12.50%), Skh (7.50%) and Sh (2.50%). The land area covered by AEU-B is 22.50%.

Agro-ecological unit C (AEU-C)

This is made up of the FCC units with sandy topsoils over loamy sub-soils, loamy top-soils over sandy sub-soils as well as loamy top-and sub-soils. But they are generally characterized by poor drainage as constraint to crop production. Table 2 revealed that FCC units of AEU-C include SLgkh (2.50%), LSgh (2.50%) and Lgh (2.50%). The AEU-C covers 7.50% of the study area (Figure 2).

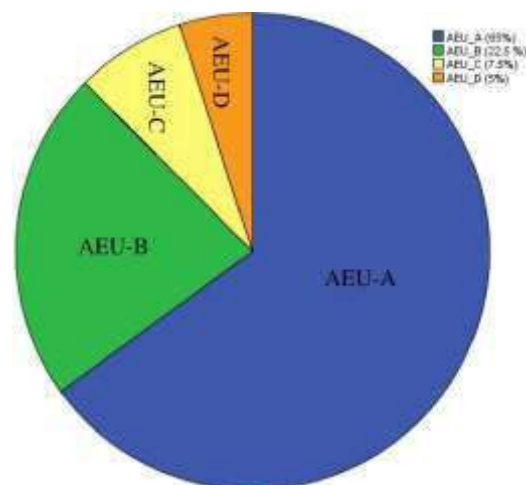


Figure 2: Diagrammatic presentation of the agro-ecological units (AEUs) of beach ridge sands area in Akwa Ibom State, Nigeria

Agro-ecological unit D (AEU-D)

Like the AEU-C, AEU-D comprised FCC units with profiles having sandy topsoil over loamy subsoil, but unlike AEU-C, are well drained profiles. One FCC unit (SLkh) represents AEU-D (Table 2). It covers 5.00% of the study area (Figure 2).

CONCLUSION

The result of this study has shown that soils derived from the beach sands parent material in Akwa Ibom State belong to 11 FCC units. Furthermore, for the purpose of efficient land use and management for optimal and sustainable agricultural productivity, the entire study area is zoned into four agro-ecological units (AEUs) based on closed similarities in certain soil profile characteristics among the 11 FCC units. The most important criteria used for the creation of the AEUs are soil texture and drainage. Accordingly, all areas with sandy and poorly drained profiles belong to AEU-A; this covers 65.00% of the study area. Secondly, all areas with sandy and well drained profiles belong to AEU-B; this occupies 22.50% of the study area. Similarly, all areas with sandy/loamy profiles with poor drainage belong to AEU-C. It occupies 7.50% of the study area. Finally, all areas with sandy/loamy profiles which are well drained belong to AEU-D, which covers 5.00% of the study area. Based on the agronomic limitations of each of the four identified agro-ecological units (AEUs), recommendations for optimum and sustainable agricultural productivity of the beach sands area of Akwa Ibom State are outlined below:

- **AEU-A:** Predominantly course textured (sandy profiles) with poor drainage (high water table) conditions- occupying 65.00% of the study area. Conscious, sustained use of organic fertilizers (manures) and mulching will improve the soil physical properties and build up fertility as well. Also, provision of appropriate drainage facilities will control excessive soil wetness by lowering the water table and create favourable rooting conditions. Furthermore, appropriate land preparation/tillage operation to increase the rooting depth as well as dry season farming, preferably vegetable production, when the soil moisture is optimum for good crop performance are recommended.
- **AEU-B:** Also have sandy profiles (as for AEU-A), but unlike AEU-A, they are well-drained. The unit occupies 22.50% of the area. Heavy applications of manures/organic fertilizers are suggested to improve soil physical conditions; plantation agriculture (tree crops and fruit production) is also recommended.
- **AEU-C:** Soils with sandy/loamy profiles with poor drainage conditions, occupying 7.50% of the study area. For this AEU, fishery and aquaculture practices are recommended with proper management to take advantage of the soil conditions.
- **AEU-D:** Soils with sandy topsoil over loamy subsoil, but well-drained profiles. Occupies 5.00% of the area. For this AEU, intensive cultivation of annual crops, with organic fertilizer application is recommended.

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