Journal of Innovative Research in Engineering and Science 2(3), May, 2011.
ISSN : 2141-8225

Suitability Evaluation of Alluvial Soils for Rice (*Oryza sativa*) and Cocoa (*Theobroma cacao*) Cultivation in an Acid Sands Area of Southeastern Nigeria *(pp. 148-161)*

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Abstract: Two soils, Alfisols and Ultisols were evaluated for swamp rice (*Oryza sativa*) and cocoa (*Theobroma cacao*) cultivation. Both soils developed from alluvial deposits in an area dominated by acid sands in Akwa Ibom State of Nigeria. Data were obtained from eight pedons, four from each of the two locations. Both the conventional and the parametric approaches were employed in the evaluation. The result showed that despite the favourable climatic factors and soil physical characteristics, there was no highly suitable (SI) land for rice and cocoa cultivation. By the non-parametric method, potentially and currently, all the soils were marginally suitable (S3) for rice cultivation. But by the parametric approach, currently, 12.5% of the pedons were marginally suitable (S3) while 87.5% were not suitable (N1) for rice cultivation. Potentially, 50% of the pedons were marginal (S3) while 50% were not suitable (N1) for rice cultivation. By the non-parametric method, potentially and currently, 25% of the pedons were moderately suitable (S2) while 75% were marginally suitable (S3) for cocoa cultivation. By the parametric method, potentially and currently, 25% and 75% respectively were marginal and not suitable for cocoa cultivation. The major constraints to rice cultivation were low water table (w), toxicity (t) and soil fertility (f); while those for cocoa were soil physical characteristics (s), toxicity (t) and soil fertility (f).

Key words: suitability evaluation, alluvial soils, rice, cocoa, acid sands, southeastern Nigeria.

1 INTRODUCTION

Alluvial soils are soils formed as result of transportation and redeposition of parent materials by river and sea which have higher organic matter content, (Young, 1976). Alluvial soils occupy about two percent of African soil, over three percent of South American soil, a quarter of the soils of India and a high proportion of the agricultural productive soils of both Pakistan and Bangladesh (Udo, 1995). These soils are boom grounds for swamp rice and other dry season crops, (Wirlow and John, 1989). Ibanga and Armon (1992) reported that alluvial soils can support the growth of sugar-cane, banana, plantain, cocoa, coffee and citrus in the less frequently flooded areas. During the dry season, when the flood recedes, alluvial soils can support the growth of maize, cocoyam, waterleaf, tomatoes, amarathus, okra pepper, fluted pumpkin, cassava and other vegetable crops.

In spite of these, crop production in upland soils has been very popular over the years while alluvial soils are grossly under-utilized. With the present experience, the upland soils are no longer available as before due to competition for it by non-agricultural land uses particularly uses, which relate to urbanization. The effect of this is that, the alluvial soils which have been left unused are attracting farmers' attention. But good understanding of alluvial soils is very limited in terms of their agricultural potentials and limitations.

Land evaluation is the process of estimating the potential of a land for alternative uses (FAO, 1976). Land evaluation tells the farmer the suitability of his land for specific uses and its limitations. This is achieved by matching land qualities/land characteristics with the requirements of the envisaged land use (Beek, 1978; Braimoh, 2000).

Recently, the Federal Government of Nigeria in collaboration with Akwa Ibom State Government has embarked on large-scale cultivation of cocoa and rice. Rice (*Oryza sativa*) and cocoa (*Therobroma cacao)* are crops of economic importance. Cocoa is a major commodity of international trade and supports the economy of the producing countries and also provides gainful employment for many people. Rice on the other land is a staple food of over 50% of the total world population, (Oyenuga, 1968). Rice is a unique crop grown both in upland and low land. Yield under lowland could reach 2.3t/ha and able to play dominant role in future production (IITA, 1989). In order to achieve success in large-scale cultivation of these crops by government and individuals, more lands have to be brought under cultivation, and alluvial soils seem to have more potential for the cultivation of these two crops (Ibanga and Armon, 1992).

However, there is paucity of information in the study area on the extents to which the land qualities of alluvial soils can satisfy the agronomic requirements of cocoa and rice. Therefore, the study was carried out to evaluate the suitability and limitation of these soils for cocoa and rice cultivation with a view to proffering appropriate management for optimum and sustainable productivity of these soils.

2 RESEARCH METHODOLOGY

Description of the study Area

Akwa Ibom State is located in Southeastern Nigeria within latitudes $4^0 30'$ and $5^0 30'$N and longitudes $7^0 30'$ and $8^0 20'$E. The State is underlain mainly by the coastal plain sands, the beach ridge sands, sandstones and alluvial deposits (Petters *et al*; 1989).

Physiographically, the landscape comprises a low-lying plain and riverine area with almost no portion of the State exceeding 175m above sea level. The climate is humid tropical with annual rainfall varying from 3000mm along the coast to about 2250mm at the extreme north with 1 – 3 dry months in the year. Mean annual temperature varies between 26 and 28°C with relative humidity of 75 – 80%.

Field work

Two locations were selected for the study. The locations were Obot Itu in Itu Local Government Area (dominated by Ultisols) and Ikpe Ikot Nkon in Ini Local Government

Area (dominated by Alfisols) both in Akwa Ibom State, southeastern Nigeria. In each location, two sites of about 15,000 – 19,000m^2 in size were selected. In each site, soil identification was carried out. At each point, using the auger, soil was examined from 0 – 120cm, at depth intervals of 0 – 15cm, 15 – 30cm, 30 – 60cm, 60 – 90cm and 90 – 120cm. The parameters examined included soil colour, mottles, texture, consistence, soil depth, drainage, stoniness and inclusion. Soils similar in these characteristics were grouped to form a mapping unit. Profile pits were sunk at location typical of each mapping unit. Each pit was described according to FAO (1990) guidelines for soil profile description. A total of 8 pedons were identified, 4 pedons in each location. After the profile description, soil samples were collected from genetic horizons from all pedons for laboratory analysis.

Laboratory Analysis

Soil samples were air-dried, sieved with a 2mm sieve and the following determinations were carried out using appropriate standard procedures. Particle size distribution was determined by the hydrometer method of Buoyoucos (1951) with sodium hexametaphosphate (calgon) as the dispersing agent (IITA, 1979). Soil pH was determined in 1:2 soil: distilled water ratio using glass electrode pH meter. Electrical conductivity was measured in the extract obtained from 1:2.5 soil: distilled water suspension using a conductivity bridge (Udo and Ogunwale, 1986). Organic carbon was determined by the dichromate wet-oxidation method of Walkley and Black (1934). Organic carbon was determined by the micro-kjeldahl disgestion and distillation method (Bremner, 1965). Available phosphorus was determined by the Bray – 1 method, (Bray and Kurtz, 1945). Exchangeable cations were extracted with IN NH_4OAC and the concentration of calcium and magnesium in the extract was determined by EDTA titranon (Jackson, 1962). Potassium and sodium by the use of flame photometer. Exchangeable acidity was extracted with IN KCI and titrated with 0.01M NaOH (Juo, 1975). Micronutrients were extracted with 0.1N HCI and the concentration determined using atomic absorption spectrophotometer (AAS). Base saturation was calculated as percentage of total ECEC occupied by Ca, Mg, Na and K. Effective cation exchange capacity (ECEC) was obtained by the summation of the exchangeable Ca^{2+} + Mg^{2+} + Na^{+} + K^{+} and exchangeable acidity (Al + H).

Land Evaluation

The conventional (non-parametric) methods as well as the parametric method were used to evaluate the suitability of the eight pedons for rice and cocoa cultivation in soils developed from alluvial deposit.

In conventional (non-parametric) method (FAO, 1976), pedons were first placed in suitability classes by matching their land characteristics (Table 1), with the agronomic requirements of rice and cocoa respectively (Tables 2 and 3).

By parametric method (Ogunkunle, 1993) each limiting characteristic was rated as shown in Tables 4 and 6. The index of productivity (IP) (actual and potential) was calculated using the equation

$$\mathrm{IP} = \frac{\mathrm{A}}{10}\sqrt{\mathrm{BCD} \ldots \mathrm{F}}$$

Where A is the overall lowest characteristic rating and B, C, D….F are the lowest characteristic ratings of each land quality group. (Udoh *et al*, 2006). Five land quality groups were used for this study and only a member of each of the five land quality groups was used in the calculation because there is strong, correlation among members of the same group. For example, texture and structure in group “s” (Ogunkunle, 1993). The five land quality groups were climate (c), soil physical characteristic (s), wetness (w), fertility status (f) and toxicity (t) (Table 1).

Potential Index of Productivity (IPp): In computing the IPp, properties that are not easily altered like cation exchange capacity, base saturation, pH and organic matter were used as part of the “f” group while the easily altered chemical properties like exchangeable K, Ca, available P, Mg:K ratio were not part of the calculation.

Current Index of Productivity (IPc): In this case, both the easily altered chemical properties like exchangeable K, Ca, available P and Mg:K as well as those used for IPp were used for the calculation of the IPc.

3 RESULTS AND DISCUSSION

When climatic requirements for rice and cocoa (Tables 2 and 3) were matched with the land quality (rainfall, solar radiation and relative humidity) of the study area (Table 1), annual rainfall and relative humidity scored 95% both for rice and cocoa cultivation (Tables 4 and 6). Also solar radiation scored 95% and 85% respectively, for rice and cocoa cultivation. This result indicates that the study area is optimum or nearly so, in terms of climate, for rice and cocoa cultivation,

Soil physical characteristics considered for the cultivation of wetland rice were soil depth and clay fraction while those for cocoa were soil depth and soil texture. Soil depth and texture were nearly optimum (95 – 85%) for cocoa cultivation in Obot Itu (Table 6). However, for the second location, soil depth and texture were constraints for cocoa cultivation as only one pedon (8) scored up to 85% while the rest scored between 60 and 40%.

For rice cultivation, both soil depth and clay content were optimum (95%) except for pedons 2 and 6 in location 1 and 2, respectively, which scored 85% in terms of clay content. However, both depth and clay content do not pose limitation to rice cultivation in the area.

Under this land quality, drainage and flood duration were the soil characteristics used for rice while only drainage was used for cocoa cultivation. The result of matching the requirements with land characteristics showed that ground water table was a very serious limitation for rice cultivation in the study area, being more serious in Obot Itu where all the pedons scored 40%. However, for cocoa cultivation, drainage was a major constraint in all the pedons. No pedon scored above 60% in the area.

Soil fertility was a serious constraint to both rice and cocoa cultivation in the study area. In the case of rice, except for ECEC in both locations and available P for location 2, all other fertility parameters (total N, pH, organic carbon, exchangeable K, Ca) were sub optimal for rice cultivation, scoring between 60 and 85%. The situation was similar for cocoa cultivation (Tables 4 and 6) in the study area.
Toxicity is a land quality, represented by active Fe in the case of rice cultivation. This was the most severe limiting factor for wetland rice cultivation in the study area. All the pedons scored 40% (not suitable) rating for rice cultivation. Similarly except for pedons 6,7 and 8 (in Ikpe Ikot Nkon) which were optimum (95%) for cocoa cultivation in terms of toxicity, other pedons (1 - 4) in Obot Itu location were not suitable for cocoa cultivation. They all scored (40%) because of high aluminium saturation which was the parameter representing toxicity as a land quality considered for cocoa cultivation.

Tables 5 and 7 show the summary of suitability aggregate scores/suitability classification under the potential and current evaluation, by the parametric and non-parametric methods, for all the eight pedons evaluated for rice and cocoa cultivation, respectively.

As shown in Table 5, by the parametric evaluation, potentially, all the pedons (1 - 4) in location 1, (Obot Itu), were not suitable (NI) for rice cultivation because they all scored below the minimum aggregate suitability class score of 25 to be considered as being suitable for rice cultivation (Ogunkunle, 1993). On the other hand, all the pedons (5 - 8) in location 2, were potentially, marginally suitable (aggregate class score 49 - 25) (S3) for rice cultivation. By the same parametric evaluation, but currently, seven pedons or 87.5% of the study area were not suitable (NI) – scoring below 25 aggregate suitability class score for rice cultivation. Only pedon 5 (12.5%) was currently, marginally suitable for rice cultivation.

From the result in Table 5, by the non-parametric evaluation, both potentially and currently, all the pedons in the study area were marginally suitable (S3) for rice cultivation. For location 1, the major land characteristics limiting rice cultivation were wetness (low water table) (w) and Fe toxicity (t) for all the pedons (1 - 4), as well as fertility limitation (f) for pedons 1 and 2. Similarly, for location 2, Fe toxicity (t) was the major characteristic limiting rice cultivation in all the pedons while pedon 7 also had fertility (f) limitation.
The result in table 7 shows that by the parametric evaluation, both potentially and currently, all the pedons (1-4) in location 1 and pedons 5 and 6 in location 2 were not suitable (NI) for cocoa cultivation. Two pedons (7 and 8), 25% of the study area were only marginally suitable (S3) for cocoa cultivation.

By the non-parametric evaluation, potentially and currently, two pedons, (7 and 8 in location 2) or 25% of the study area, were moderately suitable (S2) for cocoa cultivation. The remaining 6 pedons, or 75% of the area were marginally suitable (S3), for cocoa cultivation. For all the pedons in location 1, the major land characteristic limiting cocoa cultivation was toxicity (high aluminum saturation) (t) while pedon 1, also had fertility limitation (f). For pedons in location 2, the major factors limiting cocoa cultivation were wetness, (high water table) (w), soil fertility (f) and soil physical characteristics (soil depth and texture) (s).

By matching the requirements in Table 2 (Sys, 1985) with the land quality in Table 1, the result (Table 4), showed that climate is optimum (95%) for rice cultivation and nearly optimum (85%), for cocoa cultivation. Also by the requirements for rice cultivation, according to Moorman and Dudal (1986) and Ponnamperuma (1994), (Tables 2 and 3) in terms of soil physical characteristics (soil depth and clay content), the area was also optimum and nearly optimum for rice and coca cultivation, respectively.

However, the following land qualities, wetness/ ground water table (w), fertility status(f) and toxicity (t) were major limiting factors to rice and coca cultivation in the area. According to Tanaka and Yoshida (1970), the optimum ground water table for rice cultivation is 0 – 15cm, whereas in the study area, water table was as deep as 70 – 100cm or deeper (Table 1). Also, the optimum drainage for cocoa cultivation is moderate to well drained (Moorman and Dudal 1986), while most of the pedons in the study area were imperfectly drained (Table 1). These have rendered the area either marginally suitable or not suitable for rice and cocoa cultivation.

Similarly, most of the fertility parameters (pH, organic matter, available P, exchangeable K, Ca Mg), were suboptimal for rice and coca cultivation, by the requirements for these crops (Tanaka and Yoshida, 1970 and Lass, 1999). The most severe limitating land quality for rice and coca cultivation in the study area is toxicity – represented by high Fe toxicity for rice and high aluminium saturation for cocoa cultivation. Iron toxicity has rendered almost the entire area either unsuitable or only marginally suitable for rice and cocoa cultivation.

4 CONCLUSIONS

Climate, soil depth and clay content are optimum or nearly so, for rice and coca cultivation in the study area. However, ground water table, fertility status and toxicity have rendered 50% of the area “not suitable” for rice, potentially and currently and only 50% is marginally suitable potentially, by the parametric (more strict) evaluation method. By the non-parametric evaluation, potentially and currently, the entire area is only marginally suitable for rice cultivation. For cocoa, the situation is very similar as in the case of rice, except that at least 25% of the area is moderately suitable while 75% is marginally suitable for the cultivation of the crop.

For optimum productivity of these crops in this area, appropriate land preparation methods would be required to reduce the depth to water table and increase the suitability of the land for irrigation. Also appropriate soil amendments would be required to control the soil pH and ameliorate iron toxicity and aluminium saturation.

Table 1: Land qualities/characteristics of pedons in the study areas

Land qualities/ Characteristics	**Unit**	**Location 1 (OBOT ITU)**				**Location 2 (IKPE IKOT NKON)**			
		Pedon 1	**Pedon 2**	**Pedon 3**	**Pedon 4**	**Pedon 5**	**Pedon 6**	**Pedon 7**	**Pedon 8**
Climate (c)									
Annual rainfall	Mm	2243	2243	2243	2243	1515.8	1515.8	1515.8	1515.8
Mean Temperature	°C	26 – 28	26 – 28	26 – 28	26 – 28	26 – 28	26 – 28	26 – 28	26 – 28
Relative Humidity	%	80	80	80	80	80	80	80	80
Solar Radiation	$MJm^{-2}day^{-1}$	12.32	12.32	12.32	12.32	12.32	12.32	12.32	12.32
Soil Physical Characteristics (s)									
Soil Depth	Mm	160	100	150	150	81	70	90	105
Clay	%	47.41	43.45	41.22	45.85	45.58	49.65	42.83	34.12
Silt	%	12.63	19.85	17.44	21.63	9.61	18.54	13.15	12.17
Sand	%	39.96	36.7	41.34	32.52	44.81	61.81	44.02	53.71
Texture	–	Clay	Clay	Clay	Clay	Sandy clay	Sandy loam	Clay	Sandy clay loam
Wetness (w) or Ground water table									
Drainage	–	2	1	2	2	1	1	1	1
Flood Duration	Months	4 – 5	4 – 5	4 – 5	4 – 5	4 – 5	4 – 5	4 – 5	4 – 5
Ground water table	Cm	160	70	NE	NE	81	70	90	105
Fertility (f)									
pH		5.3	5.0	5.3	5.5	5.3	5.5	6.1	6.1
Total N	%	0.22	0.27	0.13	0.09	0.11	0.06	0.04	0.07
Organic carbon	%	1.88	2.60	1.60	2.22	1.63	0.02	1.30	1.24
Organic matter	%	3.26	4.58	2.77	3.85	2.28	0.03	2.26	2.15
Available P	$mgkg^{-1}$	10.1	10.6	7.2	10.2	15.7	23.6	26.9	20.8
Exc. K	$cmolkg^{-1}$	0.11	0.09	0.09	0.09	0.12	0.12	0.12	0.24

Exc. Ca	cmolkg^{-1}	0.90	1.9	1.8	1.5	7.6	7.5	14.2	22.2
Exc. Mg.	cmolkg^{-1}	0.79	0.93	0.86	0.94	5.24	4.62	4.94	3.21
Exc. Na	Cmol/kg^{-1}	15.52	22.18	14.55	11.97	12.34	14.6	13.84	12.36
CEC (Soil)	cmolkg^{-1}	17.32	25.1	17.3	14.5	42.7	17.6	33.1	38.0
Base Saturation	%	16.9	27.8	29.3	22.8	59.0	82.2	90.4	86.1
Toxicity (t)									
Active Fe	mgkg^{-1}	281	247	230	242	233	220	248	240
Fe	(%)	2.81	2.47	2.30	2.42	2.33	2.20	2.48	2.40
Al saturation	%	56.3	45.2	60.5	47.2	28.5	6.4	6.8	6.1

KEY: Drainage

1 = imperfectly drained, 2 = moderately drained, 3 = Well drained and NE = Not encounter

Table 2: Factor ratings of land use requirements for wetland rice

Land qualities/ characteristics	**Unit**	**S1 95 – 85**	**S2 65 – 60**	**S3 60 – 20**	**N1 40 – 20**	**N2 20 – 0**
Climate (c)						
* Annual Rainfall	Mm	>1400	1200-1400	950-1100	850-900	<850
* Solar Radiation	MJcm^{-2}day^{-1}	>478	478-358	358-239	358-120	Any
Soil Physical Characteristics (s)						
(a) Soil Depth	Cm	>20	10-20	5-10	<5	Any
(b) Clay	%	50-25	25-15	15.5	≤ 5, ≥ 5	Any
Wetness (w) or Ground water table						
(a) Drainage	–	1-3	1.3	3	any	Any
(a) Flood Duration	Months	> 4	3-4	2-3	< 2; >4	Any
(a) Ground water Table	Cm	0-15	15-30	30-60	> 60	Any
Fertility Status (f)						
++ pH	–	5.5-7.5	5.2-5.5	≤ 5.5 -	≥ 5.2 -	Any
++ Total N	%	>0.2	0.1-0.2	0.05 - 0.1	<0.05	Any
++ Organic carbon	%	2-3	1-2	3-4	> 4	Any

++ Available P	$mgkg^{-1}$	> 20	15-20	10-15	< 10	Any
++ Exc. K	$cmolkg^{-1}$	> 0.2	0.1-0.2	< 0.1	< 0.1	Any
++ Exc. Ca	$cmolkg^{-1}$	10-15	5-10	1-5	<1; >5	Any
++ CEC (Soil)	$cmolkg^{-1}$	> 16	10-16	5-10	<5	Any
Toxicity (t)						
(a) Active Fe	%	<0.75	0.75-1.0	1-1.25	>1.25	Any

Source: * Sys (1985) [(a)] Moormann and Dudal (1965)
[(b)] Ponnamperuma (1994)
[++] Tanaka and Yoshida (1970)

KEY: Drainage:

Imperfectly drained = 1
Moderately drained = 2
Well drained = 3

Table 3: Factor ratings of land use requirements for wetland rice

Land qualities/ characteristics	**Unit**	**S1 95 – 85**	**S2 85 – 60**	**S3 60 – 20**	**N1 20 – 0**
Climate (c)					
[+] Annual Rainfall	Mm	1500-2500	1200-1500	1000-1200	70-1000
[+] Average temperature	°C	29-32	21-29	18-21	<18
[+] Temperature of the coldest month	°C	19.1-17	16-17	<16	<16
[+] Mean relative humidity	%	>75	60-5	<60	<50
Soil Physical Characteristics (s)					
[+] Soil Depth	Cm	>150	100-150	80-100	<80
[+] Texture	–	Loam	clay loam	clay	Any
Wetness (w) or Ground water table					
[+] Drainage	–	2-3	2-3	2-3	Any
Fertility Status (f)					
[++] Ph	–	7.5-6.0	6.0-5.0	<5.0	Any
[++] Organic matter	%	>3.5	3.5-2.5	<2.5	Any
[++] Available P	$mgkg^{-1}$	>15	6-15	<5	Any
[++] Exc. K	$cmolkg^{-1}$	>0.31	0.30-0.11	<0.11	Any
[++] Exc. Ca	$cmolkg^{-1}$	12-6	6-3	<3	Any
[++] Exch Mg	$cmolkg^{-1}$	12-6	6-3	<3	Any
Toxicity (t)					
[++] Al Satn	%	0-10	10-25	>25	Any

Source: [+] Akwa Ibom State Ministry of Agriculture publication, Vol. II, 2003

++ Lass (1999)

KEY: Drainage:

Imperfectly drained	=	1
Moderately or poorly drained	=	2
Good or well drained	=	3

Table 4: Suitability Class scores of the study areas for rice cultivation

Land qualities/ Characteristics	Location 1 (OBOT ITU)				Location 2 (IKPE IKOT NKON)			
	Pedon 1	**Pedon 2**	**Pedon 3**	**Pedon 4**	**Pedon 5**	**Pedon 6**	**Pedon 7**	**Pedon 8**
Climate (c)								
Annual rainfall	S1(95)	S1(95)	S1(95)	S1(95)	S1(95)	S1(95)	S1(95)	S1(95)
Solar Radiation	S1(95)	S1(95)	S1(95)	S1(95)	S1(95)	S1(95)	S1(95)	S1(95)
Soil Physical Characteristics (s)								
Soil Depth	S1(95)	S1(95)	S1(95)	S1(95)	S1(95)	S1(95)	S1(95)	S1(95)
Clay	S1(95)	S1(95)	S1(95)	S1(95)	S1(95)	S1(95)	S1(95)	S1(95)
Wetness (w) or Ground water table								
Drainage	N1(40)	N1(40)	N1(40)	N1(40)	S1(95)	S3(60)	S3(60)	S3(60)
Flood Duration	S1(95)	S1(95)	S1(95)	S1(95)	S1(95)	S1(95)	S1(95)	S1(95)
Fertility Status (f)								
pH	S2(85)	S3(60)	S2(85)	S1(95)	S2(85)	S1(95)	S1(95)	S1(95)
Total N	S2(85)	S2(85)	S2(85)	S3(60)	S2(85)	S3(60)	S3(60)	S3(60)
Organic carbon	S2(85)	S1(95)	S2(85)	S1(95)	S2(85)	S3(60)	S3(60)	S3(60)
Available P	S3(60)	S3(60)	S3(60)	S3(60)	S2(85)	S1(95)	S1(95)	S1(95)
Exchangeable K	S2(85)	S3(60)	S3(60)	S3(60)	S2(85)	S2(85)	S2(85)	S2(85)
Exc. Ca	N1(40)	S3(60)	S3(60)	S3(60)	S2(85)	S2(85)	S2(85)	S2(85)

CEC Soil or ECEC	S1(95)	S1(95)	S1(95)	S2(85)	S1(95)	S1(95)	S1(95)	S1(95)
Toxicity (t)								
Active Fe	N1(40)	N1(40)	N1(40)	N1(40)	N1(40)	N1(40)	N1(40)	N1(40)
Aggregate Suitability+								
Potential	N1(22.2)	N1(18.6)	N1(22.2)	N1(22.2)	S3(34.1)	S3(27.1)	S3(27.1)	S3(27.1)
Actual (Current)	N1(15.2)	N1(18.6)	N1(18.6)	N1(18.6)	S3(24.1)	N1(21.6)	N1(18.6)	N1(22.8)

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

Table 5: Suitability aggregate scores and suitability classification of pedons for rice, indicating limiting characteristics

		Aggregate Suitability			
		Parametric		Non-parametric	
Site	**Pedon**	**Potential**	**Current**	**Potential**	**Current**
1 (Obot Itu)	1	N1(22.4)	N1(15.2)	S3wft	S3wft
	2	N1(18.6)	N1(18.6)	S3wft	S3wft
	3	N1(22.2)	N1(18.6)	S3wft	S3wft
	4	N1(22.2)	N1(18.6)	S3wft	S3wft
2 (Ikpe Ikot Nkon)	5	S3(34.1)	S3(34.1)	S3t	S3t
	6	S3(27.1)	N1(21.6)	S3t	S3t
	7	S3(27.1)	N1(18.6)	S3t	S3t
	8	S3(27.1)	N1(22.8)	S3t	S3t

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

2: f = Fertility limitation; t = toxicity limitation; w = wetness (water table) limitation

Table 6: Suitability scores of the study areas for cocoa cultivation

Land qualities/ Characteristics	Location 1 (OBOT ITU)				Location 2 (IKPE IKOT NKON)			
	Pedon 1	**Pedon 2**	**Pedon 3**	**Pedon 4**	**Pedon 5**	**Pedon 6**	**Pedon 7**	**Pedon 8**
Climate (c)								
Annual	S1(95)	S1(95)	S1(95)	S1(95)	S1(95)	S1(95)	S1(95)	S1(95)

rainfall								
Solar Radiation	S2(85)	S2(85)	S2(85)	S2(85)	S2(85)	S2(85)	S2(85)	S2(85)
Relative humidity	S1(95)	S1(95)	S1(95)	S1(95)	S1(95)	S1(95)	S1(95)	S1(95)
Soil Physical Characteristics (s)								
Soil Depth	S1(95)	S2(85)	S2(85)	S2(85)	S3(60)	N1(40)	S3(60)	S2(85)
Texture	S2(85)	S2(85)	S2(85)	S2(85)	S3(60)	S2(85)	S3(60)	S2(85)
Wetness (w) or Ground water table								
Drainage	S3(60)	S3(60)	S3(60)	S3(60)	N1(40)	S3(60)	S3(60)	S3(60)
Fertility Status (f)								
pH	S2(85)	S2(85)	S2(85)	S2(85)	S2(85)	S2(85)	S1(85)	S1(95)
Organic matter	S2(85)	S1(95)	S2(85)	S1(95)	S2(85)	N1(40)	S3(60)	S3(60)
Available P	S2(85)	S2(85)	S2(85)	S2(85)	S1(95)	S1(95)	S1(95)	S1(95)
Exchangeable K	S3(60)	S3(60)	S3(60)	S3(60)	S3(60)	S3(60)	S3(60)	S2(85)
Exc. Mg	N1(40)	S3(60)	S3(60)	S3(60)	S3(60)	S3(60)	S3(60)	S2(95)
Toxicity (t)								
Al Saturation	N1(40)	N1(40)	N1(40)	N1(40)	S3(60)	S1(95)	S1(95)	S1(95)
Aggregate Suitability+	N1(40)	N1(40)	N1(40)	N1(40)	S3(60)	S1(95)	S1(95)	S1(95)
Potential	N1(24.3)	N1(24.3)	N1(24.3)	N1(24.3)	N1(20.4)	N1(17.6)	S3(38.5)	S3(38.5)
Actual (Current)	N1(16.6)	N1(20.4)	N1(20.4)	N1(20.4)	N1(17.1)	N1(17.6)	S3(38.5)	S3(38.5)

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

Table 7: Suitability aggregate scores and suitability classification of pedons for cocoa, indicating limiting characteristics

		Aggregate Suitability			
		Parametric		Non-parametric	
Site	**Pedon**	**Potential**	**Current**	**Potential**	**Current**
1 (Obot Itu)	1	N1(24.3)	N1(16.6)	S3ft	S3wft
	2	N1(24.3)	N1(20.4)	S3t	S3t

	3	N1(24.3)	N1(20.4)	S3t	S3t
	4	N1(24.3)	N1(20.4)	S3t	S3t
2 (Ikpe Ikot Nkon)	5	N1(20.4)	N1(17.1)	S3w	S3w
	6	N2(17.6)	N2(17.6)	S3fs	S3fs
	7	S3(38.5)	S3(38.5)	S2Swf	S2Swf
	8	S3(38.5)	S3(38.5)	S2wf	S2wf

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

2: f = Fertility limitation; t = toxicity limitation; w = wetness (water table) limitation

5 REFERENCES

Bray, R. H. and L. T. Kurtz. 1945. Determination of total, organic and available forms of phosphorus in soils. *Journal of Soil Science*. 59. 45 – 49p.

Buoyoucos, G. A. 1951. Determination of particle size in soils. *Agronomy Journal* 42: 438 – 448.

FAO 1976. A framework for Land Evaluation. FAO Soils Bull. 32: FAO Rome. 87.

FAO 1990. Guidelines for Soil Descriptions. 3rd (ed.) FAO Rome.

I.I.T.A. 1989/90. Annual Report. International Institute of Tropical Agriculture. Ibadan. Nigeria.

Ibanga, I. J. and M. A. Armon 1992. Report on the wetland soils of Cross River State. Cross River State Agricultural Development Project. Calabar.

Jackson, M. L. 1962. Soil Chemical Analysis. Constable and Co. Ltd. London.

Juo, A. S. R. 1975. Selected Methods for Soil and Plant Analysis. IITA Ibadan, Nigeria. IITA *Annual series 1*.

Lass, 1999. Cocoa Growing and Harvesting Practices, in Knight (ed.) Black Well Science. American Cocoa Research Institute, 79000 West Park Drive.

Moormann, F. R. and R. Dudal 1986. Characteristics of soils in which Paddy is grown in relation to their capability classification. Soil Survey Rep. No. 32 . Dept. of Land Development, Bangok. Thailand.

Ogunkunle, A. O. 1993. Soil in Land Suitability Evaluation: An Example with oil palm in Nigeria. Soil Use and Management. 9(1): 35-40.

Oyenuga, V. A. 1968. Nigeria's Food and Feeding-Stuffs Ibadan University Press, Ibadan. Nigeria.

Petters, S. W., E. J. Usoro, E. J. Udo, U. W. Obot, and S. N. Okpon. 1989. Akwa Ibom State. Physical Background, soils and land use and Ecological Problems. Technical Report of the Task Force on Soils and Land use. Govt. Printer, Uyo. 602.

Ponnamperuma, F. N. 1994. Evaluation and Improvement of lands for Wetland Rice Production, 319p. In Rice and Problem Soils in South and South-East Asia (eds). Senadhria. IRRI, Philippines.

Tanaka, A. and S. Yoshida 1970. Nutritional disorders of the Rice plant in Asia. International Rice Research Institute Tech. Bull. 10:51.

Udo, E. J. 1995. Agricultural potential of Inland valley soils of Nigeria. A paper presented at the 29th Annual Conference of Soil Science Society of Nigeria.

Udo, E. J. and J. A. Ogunwale. 1986. Laboratory Manual for the Analysis of Soils, Plant and Water Samples. Department of Agronomy, University of Ibadan, Ibadan, Nigeria.

Walkley, A. and I. A. Black. 1934. Organic carbon. In C. A. Black (ed) Method of Soil Analysis Part 2. *American Society of Agronomy* 9: 1372 – 1376.

Wislow, M. O. and V. T. John 1989. Rice Production in Nigeria. I.I.T.A. Research Brief Vol. 9. No. 8.

Young, A. 1976. Tropical Soils and Soil Survey. Cambridge University Press, Cambridge. 468.